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BUREAU OF EDUCATION

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HIGHER TECHNICAL EDUCATION IN FOREIGN COUNTRIES

STANDARDS AND SCOPE

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION,
Washington, February 14, 1917.

SIR: To meet, to some extent at least, the demand of school officers and business men of the United States for information in regard to standards and scope of higher technical education in foreign countries, I recommend that the manuscript transmitted herewith be published as a bulletin of the Bureau of Education. This manuscript has been prepared at my request by Anna Tolman Smith, specialist in foreign educational systems, and W. S. Jesien, specialist in Slavonic languages and the history of education in Slavonic countries.

Respectfully submitted.

P. P. CLAXTON,
Commissioner.

The SECRETARY OF THE INTERIOR.

HIGHER TECHNICAL EDUCATION IN FOREIGN COUNTRIES.

INTRODUCTION.

Interest in technical education of the higher order has been greatly increased by the European war, and as a consequence numerous inquiries have been recently received at the Bureau of Education with regard to the higher technical schools of foreign countries. These inquiries relate in the main to the organization and conduct of the foreign schools, their courses of instruction, and the relative value of their diplomas. The endeavor has been made in this bulletin to meet such inquiries, whether general or specific, by means of information drawn from official and other authoritative sources.

In a broad survey of the subject it is seen that while the term technical is used often in a comprehensive sense, including commercial, agricultural, and engineering schools, it is more generally restricted to schools which specialize in engineering and the mechanical arts that involve the applications of science. In this limited sense the term is used in the present bulletin; but even this restricted province includes schools exclusively professional in their purposes and those that combine with departments of professional engineering a wide range of specialties relating to productive industry.

On account of the varying scope of technical institutions and the differences between countries in respect to classification, it is impossible to employ a uniform scheme of presentation for institutions selected as typical and equally impossible to institute exact comparisons between their programs and their standards. It may be said, however, that all the institutions here classed as higher technical, with the few exceptions hereafter noted, require the same entrance qualifications as the universities of their respective countries and confer diplomas that have equal value with the university diplomas. These two conditions afford a basis of classification which has been maintained in the bulletin. The matter presented includes therefore (1) a survey of the studies preliminary to the higher technical schools, (2) accounts of typical schools, (3) statistical summaries comprising additional institutions of the same order.

So far as possible the information in regard to each country is arranged under the given heads in the order named. The accounts of typical schools referred to under (2) include in a few instances detailed programs. These will serve to suggest the contents of the similar courses of instruction in other institutions which are presented in brief outline to avoid wearisome repetition.[1]

The courses of study preliminary to the higher technical instruction are covered by the programs of secondary schools, which in nearly all foreign countries are fixed by official decrees and are strictly maintained. Great Britain is an exception in this respect, the secondary schools of that country having large independence and individuality. At the same time the actual standard of preparation for the higher technical studies differs little from that maintained on the Continent. Hence the programs of the German gymnasia and realschulen and the French lycées, which are very fully presented under the respective countries, fairly represent European standards for admission to the higher orders of education, both general and technical. Marked deviations from these standards are discussed under the different countries considered.

It is noticeable that, while the courses of preparatory study differ in scope, stress is invariably placed upon mathematics and the elements of the exact sciences. As a rule, in European countries if a candidate for admission to a higher technical school has had mainly a classical education he is required to take such courses in mathematics, physics, chemistry, etc., as will make good his deficiencies in these studies. Thus, while the same mental maturity is demanded in candidates for the higher education, whether general or technical, it is recognized that the latter depends upon the habit of exact observation and close reasoning, which is the product of scientific training; practically, however, the two orders of higher education rest upon the same basis.

In a completely organized system of technical education the line of relation between the lower grades and the highest starts with the modeling and weaving exercises of the kindergarten, and is continued by manual training and science studies in elementary and secondary schools. The various orders of technical schools diverge from the main course of general education at successive stages: Continuation schools with a vocational bias follow the elementary grades; schools of arts and trades follow the intermediate or higher grade elementary schools, while technical schools of the secondary order require for admission two or three years of a secondary school course; the higher technical schools are distinguished from the latter by a standard of admission equivalent to the bachelor's degree or the university

[1] These accounts are derived from prospectuses, reports, and manuscript statements, for which the office is indebted to the president, director, or other officials of the respective institutions.

matriculation examination. In all European countries large provision has been made for the lower orders of technical training, and in particular provision for trade and engineering schools intended to provide directors and foremen of large industrial works. This class of institutions, which is not included in the present bulletin, has been quite fully considered in previous publications of this office.[1] As a rule, both in Great Britain and in Germany the highest technical schools have developed from schools of the secondary order, although the latter are not regarded as preparatory to the former. Even in Italy, where the two orders of technical education are closely correlated, a student from the secondary technical institutions must pass a year either in a preparatory section of the higher technical schools, or in a university faculty of sciences before he can be registered in the advanced technical courses.

The close relation between the progress of industry and that of technical education is emphasized anew in every survey of this subject. Schools of military and naval engineering pertain directly to State service, but a much higher conception of technical education led to the establishment of the technical schools that now dispute with universities supremacy in the field of higher education.

The École Polytechnique in Paris, the earliest institution of this order, was created in 1794 by men who at the dawn of the scientific movement foresaw its vast promise for great industrial enterprises. This prophetic outlook also excited efforts for the diffusion of scientific knowledge among artisans of all orders; hence in the same year there was created at Paris another institution, the Conservatory of Arts and Crafts, in which it was proposed that the history of the development of the arts and their relation to the sciences should be taught along with technical processes and methods. These two purposes have determined the subsequent development of technical education in France, and they have both affected in greater or less proportion the organization of that interest in other countries.

[1] See bibliography, p. 115.

GERMANY.

STANDARDS OF PREPARATORY TRAINING.

In Germany, as in European countries generally, the higher technical institutions draw their students chiefly from the secondary schools for general education. This preparation is also obtained in technical schools of the intermediate order.

The secondary schools.—The secondary schools of Germany, which prepare students for admission to the university and higher technical schools, comprise three types, as follows: Gymnasium, realgymnasium, and higher (ober) real school. These schools all have a nine years' course, organized in three divisions: A lower division comprising Classes VI, V, IV, intended for pupils from 9 to 12 years of age; an intermediate division comprising also three classes, untertertia (lower third), obertertia (upper third), and untersecunda (lower second), for ages 13 to 15; and an upper division comprising classes obersecunda (upper second), unterprima (lower first), and oberprima (upper first), intended for ages 16 to 18.

The work of each year in the secondary schools is tested by an examination which determines the ability of the student to pass on to the higher class. The leaving, or final examination (abiturientenexamen), which takes place when the pupil has passed through oberprima, marks the completion of the course in the full or nine-year secondary schools. The leaving examination is conducted by written papers and orally.

The written examination comprises for all the schools a German essay and the working of four mathematical questions pertaining to different branches of the subject. In respect to other subjects, the matter of the written examination is determined by the kind of institution, but in every case it is based upon the work of the upper division of the school, comprising upper second and lower and upper prima.

The oral examination comprises for all the schools Christian religious teaching, history, mathematics, and special exercises in the remaining subjects determined by the type of school.

The time-table of the realgymnasium given below represents a mean between that of the gymnasium and the higher real school. In the realgymnasium Latin is preserved, but has less time than in

the gymnasium; Greek is omitted; English is added as a second modern language; and the time devoted to arithmetic, mathematics, natural science, and drawing is increased. The distinctions will be seen by comparing the columns of totals included in the time-table.

Time-table of the realgymnasium, showing, by classes, weekly hours for each subject, with totals for the three types of institutions

Subjects.	Hours per week, by classes.									Totals.		
	VI	V	IV	L-III	U-III	L-II	U-II	L-I	U-I	Realgymnasium.	Gymnasium.	Higher real school.
Religion	3	2	2	2	2	2	2	2	2	19	19	19
German and historical tales	4	3	3	3	3	3	3	3	3	28	28	34
French			4	4	4	4	4	4	4	28	20	47
English				3	3	3	3	3	3	18		25
Latin	8	8	7	5	5	4	4	4	4	49	68	
Greek											36	
History			2	2	2	2	3	3	3	17	17	18
Geography	2	2	2	2	2	1				11	9	14
Arithmetic and mathematics	4	4	5	5	5	5	5	5	5	43	34	47
Natural science	2	2	2	2	2	4	5	5	5	29	18	36
Writing	2	2								4	4	6
Drawing		2	2	2	2	2	2	2	2	16	8	16
Total	25	25	29	30	30	30	31	31	31	262	259	262

Curricula in those subjects which are generally emphasized in preparation for higher technical studies are given, for the realgymnasia, in the following outline.

Languages—(*a*) German.—Complete mastery of the native tongue, both in speech and writing, is insisted upon. A fair acquaintance with the national literature, with understanding of the spirit of the sagas and the old Germanic world represented by them, is also a requirement. The instruction in German calls for numerous tasks executed outside the school hours (Häusliche Aufsätze), such as composition, theses, essays, reading of classics, etc.

(*b*) Modern.—French and English are the two modern languages generally taught in German realgymnasia. The study of French is given more time than that of English.

The instruction in French aims at imparting to the students an understanding of the important works of French literature of the last three centuries, and facility in the practical use of the language, both in speech and writing. The entire course of French extends over seven years, beginning with the quarta. Stress is placed on grammar and translation in the earlier period, and later upon reading and conversation. Translation into French is an important exercise in the higher classes.

The instruction in English is carried out in a similar manner, although a year less and fewer hours a week are given to it than to French. English works since the time of Shakespeare are chosen for

the literary study. Special attention is given during the last year of the course to technical and scientific English terminology.

Mathematics.—The program of mathematics in the realgymnasium is identical with that of the oberrealschule and is broader in scope than that followed in the classical gymnasia. It comprises: (*a*) Arithmetic up to the proof of the binomial theorem for indefinite exponents; (*b*) algebra through equations of the third degree; (*c*) plane geometry, including symmetry; and spherical geometry, including principles of descriptive geometry; (*d*) plane and spherical trigonometry; (*e*) introduction to the theory of maxima and minima; (*f*) plane analytic geometry.

The study of mathematics is connected with extensive work in the solution of problems.

Natural sciences.—Under this head are included botany, zoology, mineralogy, physics, and chemistry. Only general notions of biology are taught. Physics, beginning with the upper tertia and pursued to the end of the course, is studied very thoroughly, with considerable laboratory work. Chemistry begins with the lower secunda and is completed in the last year with several more important chapters from organic chemistry. Mineralogy is limited mainly to crystallography and the knowledge of chemical composition and physical properties of the popularly known minerals.

ORGANIZATION AND EQUIPMENT OF HIGHER TECHNICAL SCHOOLS.

Introduction.—At the head of the institutions for technical education in Germany are the technical high schools (Hochschulen), 12 in number, which are named from the cities in which they are respectively located (see table, p. 26). Many of these institutions were originally trade or monotechnical schools intended for practical instruction in architecture, engineering, mechanical technology, etc. As industrial necessities multiplied and their scientific bearings were more fully recognized, the scope of the schools broadened. Higher mathematics, drawing, designing, and the theory or rationale of the subjects claimed consideration. These higher elements gained more and more prominence, and eventually chemistry, chemical technology, physics, and its applications in electricity, naval architecture, surveying, forestry, etc., were added and the curriculum broadened by the inclusion of languages, political economy, etc. At the same time the equipment for practical work was lavishly supplied according to the requirements of the different technical departments. During the early period of this movement Germany was a comparatively poor country, but the rulers realized at that time that industrial and economic supremacy would depend upon the application of scientific knowledge to the workshop, the factory, and to industry in general. Under this

idea technical education was developed with a scientific spirit and methods of its own. Finally, the governments of the different German States authorized the higher schools of this order to grant the degree of doctor in engineering; hence the schools now have equal rank with the universities.

Departments.—The technical high schools of Germany all have the four departments of architecture, civil engineering, mechanical engineering, and technical chemistry. At the same time they present special features; for example, Breslau comprises five departments organized in three sections, one of which is devoted to general science; Darmstadt and Karlsruhe have each a special department of electrotechnics, which in the other schools, excepting only Hannover, is included under mechanical engineering; in Hannover this department is connected with the chemical technical department. Berlin has a special independent division for naval architecture and marine engineering, Brunswick a special department for pharmacy, Karlsruhe for forestry, and Munich for agriculture.

As a rule, the instruction for the first year is chiefly general in character; later on specialization takes place according to the branch of engineering chosen by the student.

Government.—The technical high schools are invested with powers of self-government which are exercised by the staff of professors, subject only to general supervision by the ministry of education and ecclesiastical affairs. The organization is similar to that of the academic universities. The head of the technical school is called "chancellor" or "rector." The departments of study are controlled by councils, consisting of the regular professors (ordentliche professoren), presided over by a dean or president chosen by themselves. These deans or presidents generally constitute the university senate. The main point to be noted is that the professors have practically full control of the institutions.

The teaching staff comprises:

1. Full professors (ordentliche professoren).
2. Extraordinary professors (ausserordentliche professoren).
3. Lecturers (dozenten).
4. Private lecturers (privat dozenten).
5. Assistants.
6. Honorary professors.
7. Instructors.

The staff is invariably large, and many of the professors are men of distinction who have made original contributions to science. The statutory salaries are small, being usually less than $500 per annum, but the actual emoluments may amount to more than 10 times this amount, exceeding even $20,000 per annum for men of special eminence.

Pensions are granted to all definitely engaged professors and docents, the amounts varying, however, in different German States.

Equipments.—The equipments of the several departments are ample and generally on a lavish scale. They include technical libraries, laboratories, workshops, and specialized museums.

THE HIGHER TECHNICAL SCHOOL OF BERLIN

At Charlottenburg.

The Technical High School of Berlin (Königliche Technische Hochschule zu Berlin) is situated at Charlottenburg, a suburb of that city, and is noted for its magnificent buildings and lavish equipments. The institution was founded in 1879 by the union of two existing schools and was raised to its present status by a royal decree of 1882. As stated in its charter, the purpose of the school is to afford higher training for the technical callings in State and public service, as well as in industrial enterprises, and to foster the sciences and arts pertaining to technical instruction. The school comprises the following departments (abteilungen): Architecture; civil engineering; mechanical engineering and electrotechnics; naval architecture and marine engineering; chemistry and metallurgy; general science, especially mathematics and natural history.

Every department has its technical library and ample provision of laboratories, workshops, etc.

The annual session extends from October 1 to August 1, and in addition to the long summer vacation there are two intermissions of 14 days each, one at Christmas and the other at Easter.

The student.—The student is free to choose his lectures, but he is advised to follow all the studies of the department he selects. Students may be admitted, as in the other technical high schools, who have secured the maturity certificate from a German gymnasium, realschule, or oberrealschule, also those who have the certificate from a Bavarian industrial school, or from the Royal Trade Academy at Chemnitz. Germans educated outside of Germany are admitted when their preparation entitles them to attend a school of higher instruction of equal standing. The minister of education decides as to the equivalence of the preparation. A foreign student must have a certificate showing the completion of a nine-year course of preparatory education, or its equivalent, which would entitle him to enter a university in his own country. He must also show such knowledge of the German language as will enable him to follow the instruction. There are no further requirements for the admission of foreign

students. Women are admitted under the same conditions as men. At the end of the year, or upon leaving the university, every student may obtain a certificate of the courses attended, exercises followed, and examinations passed.

Special students.—Persons who have not sufficient preparation to enter as regular students may be admitted as special students to any one of the departments. They receive credit for lectures and laboratory work, but other academic certificates are not conferred upon them. The admission of women as special students in all cases requires the consent of the minister.

Degrees.—The school confers the diplomas of engineering and doctor of engineering (see p. 24).

Fees.—The entrance fee required of all students is 30 marks ($7.50). The fee for regular courses is estimated according to the number of hours per week for each half year or semester. Lectures for regular students, 4 marks; practical work for regular students, 3 marks; lectures for special students, 5 marks; practical work for special students, 4 marks. For practical work in inorganic, organic technical chemistry, metallurgical, electrochemistry and photochemical laboratories, the charge is 85 marks per half year. The total fees for the whole year would range from 300 to 350 marks ($75 to $87.50). The fee for the examination for diploma of engineer is 60 marks ($15) for Germans and 120 marks ($30) for foreigners. The fee for examination for the diploma of doctor of engineer is 120 marks ($30) for Germans and 240 marks ($60) for foreigners.

DEPARTMENT OF MECHANICAL ENGINEERING.

The program of the department of mechanical engineering has been selected for close analysis with the view of establishing the distinctive characteristics of the system in operation at the institution.

It must be noted that the program, as reviewed in this chapter, is by no means rigid or obligatory in all its extent. The students are given a liberal measure of free choice in the selection of time in which to study a particular subject, and are expressly warned not to overtax their powers by taking a great number of subjects. They are, however, required to submit their individual plans of study to the deans of their respective departments and to follow their advice in the matter.

The department of mechanical engineering offers five options, as follows: (A) General machine construction, (B) transportation engineering, (C) electrical engineering, (D) research and operation of machines, and (E) engineering administration. The first two years are devoted to the principles of technical science common to all

mechanical branches: Specialization begins in the third year, when the courses of instruction are arranged in the following combinations: (1) A–B; (2) C–D; (3) E.

The fourth year shows further differentiation, the options A, B, and E being followed separately, and only the options C and D remaining combined. Finally, the institution offers to all students of mechanical engineering a great number of optional courses consisting of lectures and practical occupations to be followed during the four years as a means of enlarging the students' special or general education.

Subjects included in the program of the first year.

Subjects.	Hours per week.	
	First semester	Second semester
Introduction to machine construction	8	8
Mechanical technology and iron smelting	2	2
Experimental physics	4	4
Work in physical laboratory (physical measurements)	[1] 4	
Mechanics	6	7
Higher mathematics	8	8
Descriptive geometry	5	5
Study of commercial establishments	1	1
History of mechanotechnics (for A-B-E group only)	2	2
Total Group A-B-E	41	40
Total Group C-D	41	38

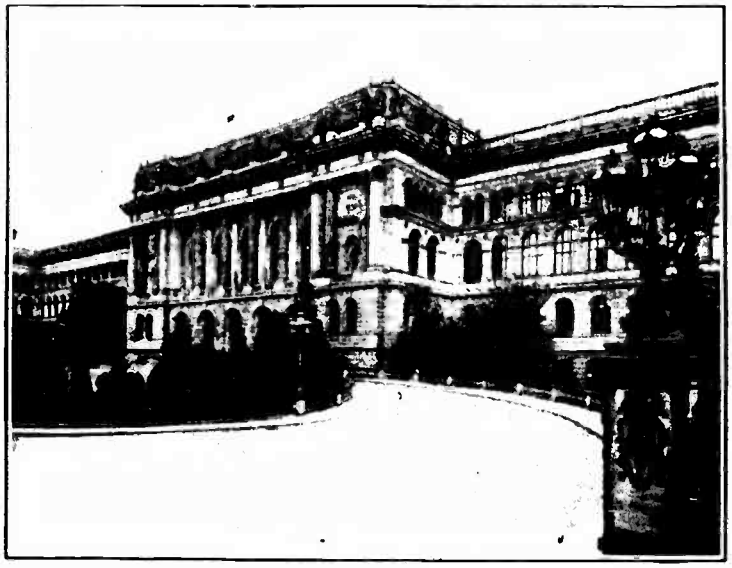
[1] Can be taken in either semester.

In the second year the course is still common to all the options.

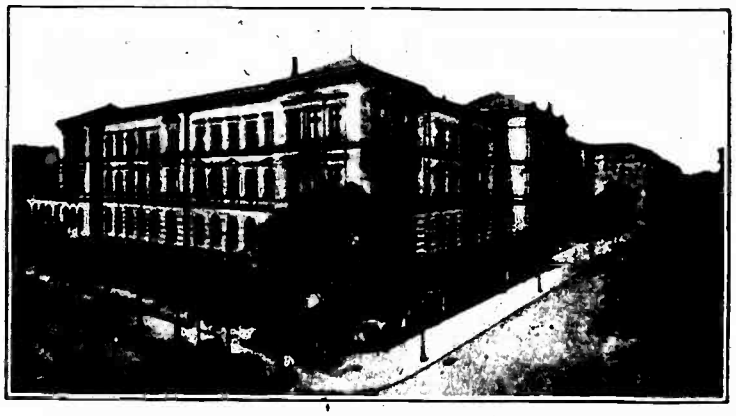
Subjects included in the program of the second year.

Subjects.	Hours per week	
	First semester	Second semester.
Elements of machines	12	[1] 8
Mechanical technology (second part) and theory of materials	6	6
Thermodynamics	2	
Exercises in mechanical laboratory		3
Mechanics, II	6	
Graphical statics	4	
Lifting machines		4
Working machines (pumps, blasting machines, and compressors—piston and centrifugal)		4
Principles of electrotechnics	4	[1] 4
Electrotechnical measurements	[1] 2	2
Exercises in electrotechnical laboratory	[1] 12	4
Selected topics in chemistry	2	
Introduction to experimental chemistry	2	2
Principles of social economy	4	4
Differential equations (group C-D only)		2
Total Group A-B-E	42	39
Total Group C-D	56	35

[1] For group A-B-E only. [2] For group C-D only.



A. HIGHER TECHNICAL SCHOOL, CHARLOTTENBURG, GERMANY.



B. THE TECHNICAL UNIVERSITY, DRESDEN.

It will be noted from the foregoing table that specialization is introduced as early as the second year, in the form of additional study in electrotechnics for students following options C and D. These two options, it may be recalled, represent, respectively, electrical engineering and research and operation of machines. The specialized work for students of the remaining group, A–B–E, occupies eight hours of study in the elements of machines during the summer semester.

The specialization becomes still more marked in the third year. The following subjects are studied jointly in classes combining several groups of options:

Subjects of the third year.

Subjects.	Hours per week.					
	A–B.		C–D.		E.	
	First semester.	Second semester.	First semester.	Second semester.	First semester.	Second semester.
Steam-engine construction (including steam turbines in all options but E)	12	13	12	4	12	.....
Internal-combustion engines and power vehicles (gas engines, gas-engine operation, oil engines, motor cars, flying machines)	2	.....	2	....	2	.....
Designing of internal-combustion machines (in group A–B combined with design of working machinery)	4	4	.....	4	4	4
Steam boilers	.....	6	.....	6	.....	6
Thermodynamics, II, including applications of heat power	2	2	2	2	2	.....
Exercises in mechanical laboratory, II	6	6	6	6	6	.....
Construction of electrical machines (in abridged scope in options A, B, and E)	2	2	12	12	2	2
Exercises in electrotechnical laboratory	4	.....	4	.....	4	.....
Elements of surface and underground construction	6	6	6	6	6	6
Technology of heating and ventilation	2	2	2	2	2	2
Methods of measurement in heating and ventilation	3	3	3	3	3	3
Banking and stock exchange operation	1	1	1	1	1	1
Political economy	.....	2	.....	2	.....	.....
Studied by A–B group only:						
Design of lifting machines	4	4	.....	.....	.....	.....
Studied by C–D group only:						
Illumination technology	.....	.....	.....	2	.....	.....
Definite integrals	.....	.....	2	.....	.....	.....
Selected topics in technical mechanics	.....	.....	.....	2	.....	.....
Exercises in electrotechnical experimental field	.....	.....	.....	4	.....	.....
Studied in option E only:						
Government	.....	.....	.....	.....	2	.....
Administration	.....	.....	.....	.....	.....	2
Business procedure	.....	.....	.....	.....	1	1
Exercises in banking and commerce	.....	.....	.....	.....	2	2
Total	48	50	52	56	49	29

In the fourth year marked specialization takes place, particularly in options B and E. The time devoted to practical exercises is increased, and in the class lectures minutest details of applied mechanics are treated.

Subjects of the fourth year.

Subjects.	Hours per week.							
	A		B		C–D		E	
	First semester.	Second semester.	First semester.	Second semester.	First semester.	Second semester.	First semester.	Second semester.
STUDIES COMMON TO SEVERAL OPTIONAL GROUPS.								
Machine tools	6	6	6	6	6	6		
Factory management	6	6	6	6	6	6	6	6
Exercises in experimental field	4	4			4	4		
Water-power engines	2	1			2	1	2	1
Design of water-power engines combined with research in a research institute for water engines	4	(1)			4	(1)	4	(1)
Water-power machines (including centrifugal pumps)	2	4			2	4	2	4
Exercises in electrotechnical experimental field, combined with designing of sketches of electrical machines	4		4	(1)				
Buildings necessary for industrial engineering works	6		4		4		4	
Buildings necessary for communal engineering works		4		4		4		4
Technology of heating and ventilation	2	2	2	2	2	2	2	2
Methods of measurement in heating and ventilation	3	3	3	3	3	3	3	3
Design of heating and ventilating installations	4	4	4	4	4	4	4	4
Design of more difficult lifting machines and of machines used in State, communal, and industrial transportation	4	(1)	4	(1)				
Design of working machines and internal combustion engines	4		4					
Advanced experimentation in mechanical laboratory	4	8			4	8		
Selected chapters from technical mechanics		2		2		2		
Statics of building construction	2	2	2	2				
Applications of electric power and electric railways	2	2	2	2	6	6	2	6
Commutator motors for alternating current	1		1		1			
Commutator motors for direct current		1		1		1		
Exercises in the Institute of economics	2	2	2	2	2	2	(2) 2	(2) 2
Review of construction of railway engines, carriages, and machinery	3						3	
Design of water-power engines and steam boilers	4				4		4	
Selected topics in higher technical mechanics	4	2	4	2	4	2		
STUDIED EXCLUSIVELY IN OPTION A.								
Testing of materials, with exercises	4	4						
Technique of refrigeration		4						
STUDIED EXCLUSIVELY IN OPTION B.								
Locomotives and self-propelling cars			6	6				
Railway operation, buildings, and signaling				2				
Training college work			2	2				
Construction of railway cars and brakes			2	2				
Iron bridge work and complicated engineering construction			6	6				
The iron constructions of the civil engineer			6	6				
Essential features of railway-station design								
Larger depots, safety systems, railway operation			6	6				
STUDIED EXCLUSIVELY IN GROUP C–D.								
Exercises in the electrotechnical experimental field					4			
Long distance electric transmission, including wireless telegraphy					4	4		
Exercises in laboratory for long distance electric transmission					4	6		
Construction of instruments and apparatus of measurement and long distance transmission					2			
STUDIED EXCLUSIVELY IN OPTION E.								
Design of machines for elevating and transportation							4	
History of technical science							2	2
Political economy								2
Patent and trade-mark laws								2
Building laws							2	
Total	81	61	83	73	78	65	46	38

(1) May be studied in either semester. (2) Optional.

The program of detached optional subjects for additional study during the four years, with the view of further specialization or of enlarging the student's general education, comprises a list of 85 subjects. The part for specialization offers a great variety of studies which make it possible for the students to go into the deepest details of their chosen branch. Those interested in aeroplanes may take advantage of a series of courses such as: Aerodynamics and mechanics of flying machines; motor airships; flying machines; exercises in construction of flying machines, etc. Those whose predilection is toward railroad engineering may further specialize in this line by taking a number of optional subjects such as: Railroad superstructure; electric interurban lines; city railways, etc. The full number of optional courses for specialization is 57; of general education, 28.

Foreign languages are included in the specialization group. Three foreign languages are offered: French, English, and Russian. There are language courses for beginners and for advanced students.

The group for general education includes mostly physico-mathematical subjects, though it contains also subjects like law, political economy, history of German industry, workmen's accident insurance laws, etc.

The examination of the program shows the following characteristics to be the most distinctive:

1. A great number of subjects, all taught by specialists.—The department of mechanical engineering offers 164 subjects, including the supplementary courses mentioned above. A professor is seldom charged with teaching a large group of subjects; three or four closely connected subjects, or rather divisions of one subject, are considered the limit of one man's capacity. This system presents great advantages, since it leads to the employment of experts in every specialty offered by the engineering science. Many professors of the division of mechanical engineering, as well as those of other divisions, actually are experts or inventors who had gained wide recognition prior to their engagement to teach in the institution. Among the prominent professors in this department may be mentioned Kammerer, Stavenhagen, and Von Parseval, builder of one of the first dirigibles.

2. A great amount of time devoted to study.—The average daily time devoted to lectures and practical occupations is 8 hours, from 8 a. m. to 6 p. m., with 2 hours' interval taken usually between 12 and 2 p. m. On Saturdays the institution closes at noon, although in the higher courses practical exercises are occasionally arranged for Saturday afternoon hours. The average weekly number of periods is especially high in the fourth year, when it reaches 70, or even 80, hours, or about 12 hours a day. The additional time is

taken early in the morning, from 7 a. m., or in the evening, until 7 or 8 p. m.

3. *The large proportion of time devoted to practical work.*—There is a distinct division made in this respect between the first two and the last two years. The relation of practical work to the entire time of study during the first and the second years is from 38 to 44 per cent, while in the third and fourth years it keeps on the level of 65 per cent, with only a drop to 61 per cent in the second semester of the third year.

The actual proportion of time given to practical occupations is the following:

Percentage of time given to practical exercises.

Years.	First semester.	Second semester.
	Per cent.	*Per cent.*
First year	43	44
Second year	38	44
Third year	65	61
Fourth year	65	65

This relation is further illustrated by diagrams 1 and 2:

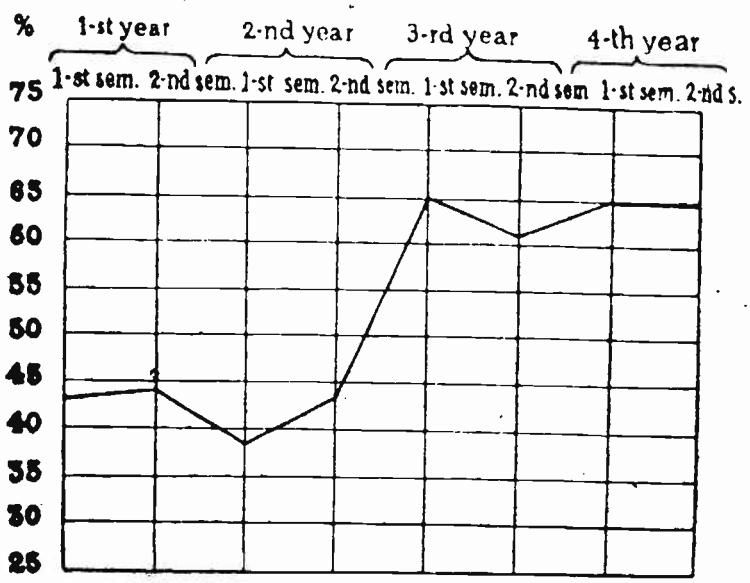


DIAGRAM 1.—Percentage of time given to practical exercises at Charlottenburg.

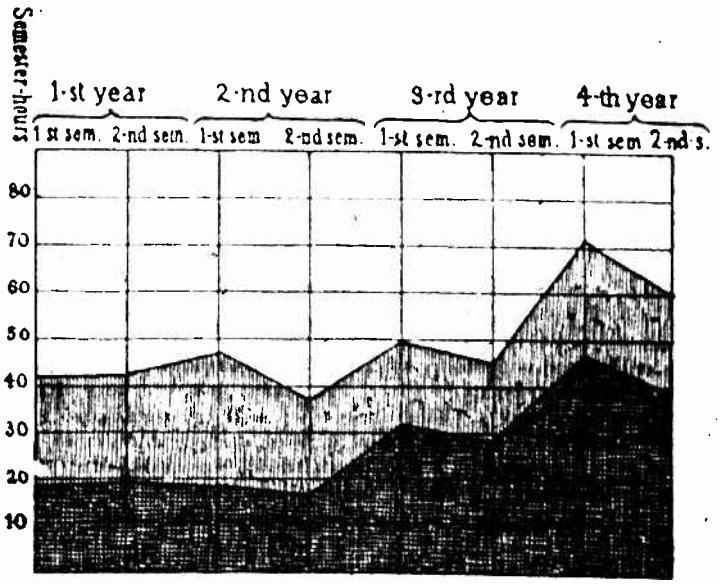


DIAGRAM 2. Curves showing total time and time devoted to practical work at Charlottenburg

Most of the practical work is done in the laboratories of the institution, which are numerous and exceptionally well equipped. The school has no arrangement for employment of students in private plants for practice during the school time. The practical work is arranged intermittently with lectures.

The remaining departments are developed with equal completeness as regards detail and grouping. It will suffice to indicate their scope by outlines of the entire course, or that for selected years

DEPARTMENT OF CIVIL ENGINEERING.

First year.—Experimental physics; higher mathematics; descriptive geometry; mechanics; elementary geodesy; geodetic practicum; exercises in surveying; experimental chemistry; constructions in wood and stone; study of machines; elements of political economy.

Second year.—Definite integrals and differential equations; mechanics; graphical statics; plan drawing; geodetic practicum; higher geodesy; general mineralogy; general geology; mechanical technology; theory of examination of materials with practical exercises; building construction in wood and stone; construction of roads; machines; machine construction and motive powers; theory of architectonic form; metallurgy of iron; general theory of political and social economy; introduction to jurisprudence and political science; commercial enterprise.

Third year.—Statics of building construction and exercises; stone and wooden bridges; railway construction; main requirements for railway stations; railway buildings and other constructions for rolling stock, etc.; foundations; practical hydraulics;

floodgates, canal construction, and locks; construction of banks and weirs; iron construction in connection with civil engineering; reinforced concrete and its structural uses; railway engines (locomotives, carriages, and mechanical arrangements); theory of potential; calculus of variations.

Fourth year.—The constructive works in railways (including tunneling and the establishment of large railway stations); iron bridges and difficult iron constructions; movable bridges; sea and harbor works; canalization, etc., including agricultural technology; water supply of cities; drainage of cities; electric railways; sketch pertaining to naval architecture; seminar for municipal buildings; examination and testing of water traffic in large cities; theory of functions.

DEPARTMENT OF ARCHITECTURE.

LECTURES AND PRACTICAL EXERCISES.[1]

First year.—Descriptive geometry [2] (I and II); experimental physics (I and II); introduction to experimental chemistry; elementary geodesy; statics of building construction (general); statics of building construction (theory of strains and stresses); theory of building construction; ornament drawing; ancient architecture; ancient art; plastic art and painting in connection with middle-age architecture; plastic art and painting of the early renaissance in Italy; plastic art and painting of the high renaissance in Italy; scientific principles of architecture and art; ornamental modeling; figure modeling; principles of political economy; exercises in architectural sketching in Berlin museum; sketching from middle-age profiles and ornamental parts of all kinds; figure drawing from copy; landscape drawing and painting from examples and from nature in every technique, pencil, pen, color; history of mechanical arts of the Romance peoples; exercises in decorative plastic of the Italian renaissance; history of civilization in the Italian renaissance; history of mechanical arts of the Germanic peoples; development of museums and museum technique.

Fourth year.—The program of the fourth year comprises 42 courses, including, however, the duplication of several subjects, which affords the student the advantage of a choice of professors treating the same, or presentations from different points of view. The program includes the following topics which in 1913–14 were in charge of 18 different professors:

Mechanisms (I and II); history of ancient architecture, Egyptian, Oriental, and Grecian; history of Roman architecture and medieval church architecture; scientific principles of building and art, practical exercises; history of architecture, Etruscan, Roman, and modern Persian; history of civilization, Italian renaissance; municipal architecture; colored decorations; designing details of architectural construction and interior decoration; seminar pertaining to municipal buildings; foundation construction for municipal buildings; elements of railway, road, bridge, hydraulic, and machine constructions; landscape sketching and painting from models and from nature, with pencil, pen and ink, brush, etc.; principles of ornamentation; designs for church furniture, utensils, etc.; designing ornamental details; medieval architecture and designs in stone, brick, and wood; Gothic architecture; designing figures according to given elements; brick construction in all styles; most important kinds of public and private constructions and city buildings; architecture of the renaissance; designs of buildings according to instructions; practice in architectural sketching; ancient art; modeling and drawing from nature; designing figures according to given instructions; drawing from life; baroque and rococo (general history of style,

[1] Announced for the year 1913-14.

[2] The Roman numerals in parentheses show that the course is given in both terms of the year.

decoration, industrial art); philosophy of architecture; interior designs, rooms, wall decorations, etc.; lighting and heating; rural architecture; adaptations of architecture to landscape.

COURSES IN TECHNICAL CHEMISTRY.

The program of the first year in technical chemistry, it will be noticed, is intended to give the students training in basic elements of mechanics and chemistry, as well as in methods of scientific study and experiment, such as chemical analysis, microscopy, spectral analysis, crystallography, etc. The first year includes also differential and integral calculus and analytical and descriptive geometry, which constitute a mathematical preparation indispensable for higher technical studies in all branches. As a large part of industrial chemistry deals with vegetable matter (chemistry of food products, chemistry of fats and oils, chemistry of dyestuffs, etc.), the program of the first year includes a course in systematic botany, in mycology, and in morphology and physiology of plants.

The second year extends and deepens the training in scientific methods and elements of science to which the first year was primarily devoted. It also is designed to impart to students a fundamental knowledge of organic chemistry and chemical technology.

The third year deals with the industrial and agricultural applications of chemical science. The subject is divided, therefore, into special branches corresponding to these applications, viz, chemistry of food products, photochemistry, electrochemistry, ceramics, etc. At the same time the study of general chemistry is continued; organic chemistry, chemical technology, and history of chemistry receive ample consideration. Exercise in analytical experimentation is continued, but with increasing relation to practical purposes.

The fourth year covers practical occupations in manufacturing processes based on chemical changes. It includes the technology of tar dyes, manufacture of oils and fats, carbohydrogen oils, thermochemistry, technology of sanitation, sugar industry, etc. Practical laboratory work has a prominent place in the course. There is also such instruction in architecture and mechanical engineering as may be useful to a chemist in a responsible position.

The development is indicated by the outline of the courses in technical chemistry for the first and the fourth year, as given below:

First year.—Elements of differential and integral calculus and analytical geometry; elements of mechanics; elements of descriptive geometry; experimental physics; experimental chemistry (metalloids, metals); crystallography and mineralogy; practical work in the inorganic laboratory; mechanical technology; general botany; machines with exercises in machine drawing (I and II); special botany; microscopy; exercises in the physical laboratory (physical measurements).

Fourth year.—Technology of coal-tar products and their uses in dyeing, printing, etc.; practical work in the technico-chemical laboratory; the spectrum and spectral analysis; investigation of sugars; precautions against accidents (industrial hygiene, technical part); physico and electro chemistry with laboratory work; thermochem-

istry; physico-chemical exercises; examination of vegetable and animal fats, oils, and wax; examination of mineral oils and other naptha products; organization of chemical laboratories and plants; principles of construction of use to industrial managers.

DIPLOMAS AND DEGREES.

In accordance with a royal decree issued on the occasion of its jubilee celebration (Oct. 11, 1899), the Charlottenburg school is authorized to confer the diploma of engineer (Diplom-Ingenieur) and that of doctor of engineering (Doktor-Ingenieur); subsequently the right was extended to all the other German technical high schools. The diploma of certificated engineer is conferred in virtue of an examination which tests the preparation of the candidate by academic and scientific studies for independent professional activity in his chosen subject. This is inscribed in each case upon the diploma. The candidate for the diploma of doctor of engineering must have secured the lower diploma, and must present a thesis on a scientific subject pertaining to his specialty. When the thesis has been approved, the applicant for the doctor's degree must submit to an oral examination covering the subject matter of his specialty.

SCHOOL FOR MINING ENGINEERING, FREIBERG, SAXONY.

The technical high school at Aachen is the only one that makes provision for mining engineering. This branch is the province of special schools or academies of which the mining school at Freiberg, Saxony, founded in 1765, is the most renowned. The school comprises three sections, for mining engineers, for mine surveyors, and for engineers in iron works, respectively. Each section offers a four years' course of instruction. The entrance requirements are similar to those of the other technical high schools. Candidates must be at least 18 years of age, and must offer the maturity certificate of one of the nine-year secondary schools of Germany, or give proof of equivalent preparation. Foreigners must not only show certificates of equivalent value, but must be sufficiently familiar with the German language to follow the instruction with profit; their papers must be officially translated and legalized by the consul, minister, or ambassador. Special students include adults who have already had a technical or scientific training, or young men who desire to advance themselves in some special branch of science.

The entrance fee for German students is 12 marks, for foreigners 24 marks; in addition 3 marks are required for insurance against accident or sickness. The fees for lectures are 6 marks for weekly lectures for the whole school year; the weekly fee for practical exercises is reckoned at the rate charged for a course of weekly lectures. The degrees conferred are mining engineer, mine surveyor, and engineer in iron works. The examination fees for the degrees are 50 marks for German citizens and 100 marks for foreigners.

The courses of instruction are highly specialized and in the section for mining engineers include, besides the technical branches, the following: Political and state science, general law, mining law, colonial mining law, social insurance, designs for mining and metallurgic buildings, mine and metallurgic statistics.

The elaboration of the course of instruction in national and state economics is significant. The syllabus includes:

Fundamental conceptions. Necessities of life. Goods value. Intercourse. Wealth. Economics. National economy.

Production. Nature. Work and capital as factors in production. Productive cooperation.

Circulation of goods. Commerce, traffic, commercial policy. Money, credit, and price.

Distribution of goods. Income, wages, interest, contracting profits. Ground rent. National income.

Consumption. Manner of consumption. Economical and extravagant luxury Equilibrium between production and consumption. Economic institutions. Insurance.

Development of national economy. Antiquity and middle ages. Mercantile system. Physiocratic system. Adam Smith. Free trade and protection. Communism, socialism, and anarchism. Social reform.

Financial science. State expenditure. Productivity of same. State revenues. Private revenues. Fees and taxes. State economy. State credit and debt. Voluntary and forced loans. Amortization. Organs of financial administration.

The course in mining and metallurgical statistics includes:

Definition and aims of statistical science, methods of investigation, aids thereto. Importance of statistics for economy and practice. Statistics of the mines, metallurgical, and salt works of the various countries, having special reference to any variations, and their causes. Statistics of imports, export, consumption, and prices in mining and metallurgical industries. Wages and workmen.

ROYAL TECHNICAL SCHOOL OF SAXONY.

This school, founded at Dresden in 1828, is intended to afford the complete scientific and artistic development required for technical professions and for the preparation of teachers for technical scientific branches, including pure mathematics, physics, and chemistry.

The school is divided into the following departments: Architectural engineering, mechanical, chemical, and general. The scholastic year begins at Easter, but the student can enter at the commencement of either the winter or summer semester.

The requirements for entrance are similar to those of other technical schools, i. e., the maturity certificate of a German gymnasium, realgymnasium or oberrealschule, the trade academy at Chemnitz, or a Bavarian industrial school. The equivalence of a foreign certificate to the German maturity certificate is decided by the rector. Hearers and visitors are admitted as in other technical schools. Women are admitted under the same conditions as men.

Lectures begin in October and end in March. Fees for lectures, exercises in groups, and seminar exercises are 4 marks for one hour

each week per semester; for other exercises 3 marks. Foreigners, in addition to the regular fees, pay 50 marks for the winter semester. The fees for the diploma examination are as follows: Fifty marks for the preliminary examination, 75 marks for the principal examination, and 4 marks for business expenses, total 129 marks. For foreigners the fees are doubled.

Statistics of the technical high schools of Germany.

Locations.	Students.[1]	Expenditure, 1912–13.	
		Marks.	United States currency.
Aachen	714	811,421	$193,118
Berlin	2,417	2,125,864	505,956
Brunswick	209	278,583	66,304
Breslau	288	2,165,246	515,328
Danzig	821	680,265	161,903
Darmstadt	999	771,300	183,569
Dresden	1,328	1,671,534	397,825
Hannover	1,309	817,446	194,552
Karlsruhe	1,096	505,232	120,245
Munich	729	928,654	221,020
Stuttgart	904	575,021	136,855
Freiberg, Saxony, Mining Academy	422	442,500	105,315

[1] Winter semester 1914–15.

FRANCE.

DISTINCTIVE CHARACTERISTICS OF TECHNICAL EDUCATION.

The general scheme of technical education in France differs from that of other European countries as a consequence of the influences under which it originated. French savants were the first to foresee the significance of science in the realm of art and industry, and the early period of the Revolution was marked by the creation of national institutions for utilizing the forces and furthering the conquests of science. Chief among the institutions created at that time were the Museum of Natural History (1793), attached to the Jardin des Plantes and intended to serve as a center of demonstration and research; the Conservatoire des Arts et Métiers (conservatory of arts and crafts), created by a decree of 1794, and intended to foster the higher technical training of artisans; and the École Polytechnique, also created by decree of 1794, a school of engineering intended to prepare artillerists and engineers for the army and navy and technical experts for various public services.

The three institutions named are still flourishing, and while they differ greatly in spirit and methods they are alike in the emphasis they place upon pure science and the unity of the sciences as factors in the higher technical education.

Provision for the lower order of technical education arose from time to time as industrial conditions demanded, and measures were eventually adopted looking to the classification of the various agencies engaged in this work.

The congress on technical education held at Paris in connection with the Universal Exposition of 1889 recognized three orders of technical education, primary, secondary, and higher. These, however, do not form stages in an ascending series; each order has its distinct purposes and agencies. In the higher technical institutions the arts and sciences are pursued with reference to their application to technical professions required in the State service, either directly or indirectly, through the promotion of great enterprises.

PRELIMINARY EDUCATION—GENERAL AND MATHEMATICAL.

For admission to the higher technical institutions applicants must have completed the full course of secondary education comprised in the lycée program. This course is organized in two cycles: The lower cycle covers four years and leads to a certificate which has value for

students entering at once upon business or industrial pursuits. The higher cycle, covering three years, completes the full course leading to the bachelor's diploma which is required for admission to the universities and higher technical schools. In the lower cycle the studies are arranged in two courses, classical and modern, between which the student has choice. The second cycle comprises three years, of which the first two offer four options as follows: 1. Latin-Greek; 2. Latin-modern languages; 3. Latin-science; 4. Science-modern languages.

In the last year the lycée program is divided into two parts, philosophy and mathematics.

It will be seen that provision has been made in the lycées for all the orders of secondary education, from the purely classical to the strictly modern. It does not follow, however, that the pupils who contemplate higher technical studies must select the extreme realistic course. The classical studies are still so much in vogue in France that Latin is generally demanded even in preparation for technical careers. Absolutely essential, however, for those intending to enter the École Polytechnique is the "classe de mathématiques" of the last year of the lycée course.

Courses im mathematics.—The program of mathematics studied in this class deserves special attention in view of its relation to higher technical studies. It is universally recognized that higher technical education calls for special mathematical preparation. The French system goes further than any other toward the solution of this question. The "classe de mathématiques" represents a distinct attempt to improve the mathematical preparation of graduates in view of the requirements of higher studies.

The mathematics is given eight hours a week and consists of review study with special emphasis on the theoretical and philosophical side of mathematics. The mathematical subjects that have been studied earlier in the lycée course are now reviewed with reference to the theoretical basis of mathematical science. The training thus secured is further systematized and unified by the course of scientific philosophy pertaining to the classification and hierarchy of science and the methods by which it operates.

Viewed in the light of its relation to higher mathematical or technical studies, this course reflects the spirit that places the development of the student's intellect above that of his specific aptness in application of formulas to the solution of mathematical problems. The entire course of the "classe de mathématiques" has the obvious aim of developing mathematical habits of mind in the wider sense, the ability of the student to attack successfully new problems, and to pursue intelligently the study of new subjects.

CONSERVATOIRE DES ARTS ET MÉTIERS.

The ministry of commerce, industry, posts, and telegraphs is charged with the general direction of the Conservatoire des Arts et Métiers; its administration is intrusted to a director and council. The council is a highly representative body which includes, besides the director of the institution, the director of technical eduction in the department of commerce, the president of the municipal council of Paris, the president of the educational commission of that council, the president of the Paris Chamber of Commerce, the president of the Society of Civil Engineers, a senator appointed for four years by the President of the Republic, and members selected from various learned bodies and public services. The membership of this council illustrates the comprehensive character that was impressed upon the institution at its foundation and which has been steadily maintained. Committees are also appointed by the minister of commerce for the direction of the various departments of the institution.

Courses and methods of instruction.—The courses of instruction in the conservatory include mathematics, especially geometry, the sciences related to the industrial arts—mechanics, chemistry, electricity, and physics, together with industrial processes and the application of motive powers. The theoretical instruction is imparted by eminent specialists in the respective subjects, who demonstrate principles and processes by means of the illustrative material comprised in the elaborate museums of the institution.

It was intended from the first that the lecture courses of the conservatory should bear the same relation to the sciences considered in their industrial relations as those at the College of France bear to the entire realm of knowledge. The professors attached to the conservatory keep watch of all the latest industrial changes and explain the most recent improvements. The courses of lectures run from two to three years according to the subject dealt with. The instruction thus imparted is of a scientific and advanced character, but none the less practical and adapted to the various classes of students, who represent different occupations, i. e., constructors of bridges and roadways who intend to become engineers, foremen or workmen who attend in the interests of their employers, heads of factories, and also engineers. The subjects are presented with clearness and lucidity, and the hearers profit according to their needs and attainments.

As the lectures are maintained for persons engaged in business or industrial pursuits during the day, they are given in evenings from November till April. The lecture courses in technical subjects are held twice a week; those in commercial law, industrial and commercial geography, and social economy and hygiene are held only once a week. All the lectures are free to the public.

The students supplement the lectures by exercises and manipulations carried on at the institution by visits of observation to factories and workshops, and by practical work. All students are expected to execute plans, accompanied by explanatory memoranda, of the following objects: Metallic bridges, steam engines, civil constructions, and machine tools for the second year; manufacture of chemical products, workshops for machine construction, locomotives, blowing machines, hydraulic establishments, etc., for the third year. The idea governing the instruction is that industrial science is a unit, and every industrial worker must know it in its entirety. Hence each student follows the same course until the end of the second year, when specialization is allowed in the following branches, according to the chosen career, i. e., machinists, constructors, metallurgical miners, and chemists.

Extensions of the curricula.—Great attention is paid to subjects that promote the interest of artisans in the history of their respective arts, and more particularly their interest in the relations between the industrial arts and the general social welfare. A chair of the "history of industry" is maintained at the charge of the city of Paris, which makes an annual appropriation for its support. "The chair of insurance and social providence" was established by mutual agreement of the State and the Paris Chamber of Commerce, each contributing $1,000 a year toward its maintenance.

The equipment of the conservatory comprises eight important laboratories, which serve for original research on the part of the professors, as well as for practical exercises by the students. The laboratories are also centers of experiment and research carried on by scientific men and industrial experts.

Certificates.—At the end of the year certificates are conferred, the standing of candidates being ascertained by estimating the marks given for the drawings and designs executed and work done in the professor's laboratory. At least a total of 14 marks on a scale of 20 is required for the certificate.

Candidates for the annual certificates relating to the full period of at least two courses which are complementary and have the same industrial or professional aim in view may obtain the diploma of studies of the conservatory by passing another general examination.

In 1912–13 the courses were attended by 2,127 persons. Of this number 237 asked permission to take the examination. Some of them already held as many as five certificates.

Financial support.—Complaint has recently been made by French leaders that the conservatory has not been adequately supplied with funds or equipment to meet the rapidly increasing scope and complexity of modern industry. It occupies, however, a unique place in the group of institutions which have made Paris a notable center of technical education.

ÉCOLE CENTRALE DES ARTS ET MANUFACTURES, PARIS.

The Central School of Arts and Manufactures is intended to train engineers for all branches of industry and for public works and services which are not necessarily under State control.

Admission requirements.—Admission to the school is by examination, which is held annually in Paris during the first 15 days of June. The fee for examination is 60 francs ($12) which is required of every applicant. Candidates must be 17 years of age on the first of January of the year of examination. Foreigners are admitted under the same conditions as Frenchmen. No diploma is required. The examination is both written and oral, and includes the following subjects the ratings for which are given:

Written examination.		*Oral examination.*	
Mathematics and mechanics	5	Analytical and mechanical geometry	5
Composition in French or other language	4	Arithmetic, algebra and analysis, trigonometry	5
Descriptive geometry	3	Elementary and descriptive geometry	5
Trigonometry and numerical calculus	3	Physics	5
Physics	2	Chemistry	5
Chemistry	2		
Architectural drawing	4		
Machine drawing	2		
Machine sketching	2		

Candidates having the bachelor's diploma or the certificate showing completion of the first part of the baccalaureate examination, receive 15 marks to their credit in the ratings.

Candidates who request the privilege are admitted to an oral examination in one or two languages, namely, English, German, Spanish, Russian, French. The language used in the examination itself must be different from that for which the special examination is requested. Those who obtain a rating above 10 receive for one language from 2 to 25 marks in addition to those granted for the general examination; for a second language, 1 to 15 marks.

The written examination includes a thesis which is marked in respect to orthography, language, and style. The thesis may be written in French or any official language.

Candidates should be accustomed to machine and architectural drawing and aquatint, and they are advised when preparing for the examination to give special attention to rapidity of execution, exactness of outline, and delicacy in touch.

At the time of the examination the candidate must present collections of drafts, machine and architectural drawings, and free-hand sketches.

Examinations and diplomas.—The school is limited to day students, and exercises no supervision of them outside of school hours.

Periodical examinations are held to determine the progress of students, and those who do not profit by the instruction are eliminated.

The marks obtained at the ordinary examinations as well as those for designs, vacation work, and final competitive examination serve to make up the student's graduating standing. The final examination consists in the execution of a general plan and the composition of a memorandum to support it. Thirty days are allowed for composing the plan, and the student must be present personally and discuss his work before the examining jury.

The diploma of engineer of arts and manufactures is given to those who obtain a total average of 14 credits on a scale of 20. Students who fail, but who show sufficient knowledge, receive a certificate of capacity (the average required being 13 credits). Such students may try a second time for a diploma within the five following years. The diploma fee is 100 francs ($20); if a student fails to pass, half the fee is returned to him.

Expenses.—The course of instruction covers three years. Tuition fees, including cost of experiments, are 900 francs ($180) for the first year and 1,000 francs ($200) for each of the two following years. The cost of supplies and drawing material must be borne by the students. The minimum cost of tuition and maintenance is estimated at 3,000 francs ($600) a year.

ÉCOLE POLYTECHNIQUE.

The École Polytechnique pertains to the ministry of war and may be regarded as the center of a system of schools preparing for the Government service. The course of instruction in the school covers two years, but the students almost without exception are intending to complete their specialized training in some one of the related schools of application. Several services of the State, viz, those requiring mining engineers, hydrographic engineers, directors of powder plants, etc., are open only to graduates from the École Polytechnique.

Admission requirements.—Candidates for admission to the École Polytechnique must be native or naturalized Frenchmen and must be at least 18 years of age and not above 21 years on the 1st of January preceding the examination. This examination is severe and competitive, the purpose being to limit admission to students of exceptional promise. Only those who have secured the diploma of bachelor are eligible for the examination. Students who have successfully completed any division of the lycée course may be admitted to the examination, but those who have studied Latin are accorded an advantage of 15 points in estimating the examination, and the same advantage is also accorded to bachelors whose diplomas carry mention of philosophy. The stress of the admission exami-

HIGHER WAR SCHOOL, PARIS.

nation is placed upon mathematics, which in both the oral and written parts is accorded more than half the whole number of possible points. The severity of this test precludes its passage by students who have not passed through the special class of mathematics in the lycée or received equivalent instruction elsewhere. From the relation of the school to the State service it follows that foreigners are only admitted by special arrangements.

Candidates for admission to the entrance examination for the École Polytechnique are not necessarily graduates from the lycée, but may have received their preparation elsewhere, as is the case with candidates for other competitive examinations. Since, however, their scope and standards are determined by the lycée program, those prepared elsewhere are at a great disadvantage.

Program.—The program of studies for the polytechnique consists almost entirely of mathematics and applied science, as indicated by the following conspectus:

Calculus.—Differential and integral—two years.

Descriptive geometry.—Different methods for the representation of bodies, a study of the principal geometrical surfaces, the construction of models—one year.

Stereotomy.—Carpentry and stonecutting—one year.

Mechanics and machinery.—Theoretical study completed by the construction of models, the designing of new machines, etc.—two years.

Physics.—Thermodynamics, electricity, and magnetism—two years; acoustics and optics—one year; laboratory practice—two years.

Chemistry.—Organic and inorganic, accompanied by experiments—two years.

Astronomy and geodesy.—Practical work—one year.

Architecture.—Theory and the drawing of designs and plans—one year.

Military art.—Two years.

History, geography, and literature.—The military, political, and moral history of the principal nations of Europe during modern and contemporaneous times, compositions on historical topics—two years.

German language, drawing from objects, coloring.—Two years.

English language.—Optional.

Practical exercises.—Laboratory and workshop practice, the designing and construction of models, are required whenever possible. The instruction in drawing and designing is very elaborate and the work executed by the students is subjected to rigid examination. In addition to the school instruction, students are also taken on visits of observation to the observatory and to manufacturing establishments in and around Paris. The régime of the school is military. All the students are exercised in military tactics, in horseback riding, fencing, and general gymnastics. The military training and conduct while at the school, however, is less severe than that at the special military schools.

Fees and scholarships.—The students board at the school and wear a uniform. The cost to the students is about $200 (1,000 francs) for tuition and board per year. The outfit and incidentals cost

each year form $140 to $150 more (700 to 750 francs). The Government, however, makes liberal provision of scholarships available for students of great promise who otherwise might not be able to bear the expense of the training. These scholarships are of four grades as follows: (1) Full scholarships; (2) half scholarships; (3) scholarships carrying relief from outfit and incidental expenses; (4) scholarships carrying half relief from outfit and incidental expenses.

Services.—As already stated, the polytechnique does not prepare directly for the Government service, but for certain schools of application, each giving instruction preparatory to some special service. The choice of the service to be entered upon is not made by the students until their graduation from the polytechnique, and is determined finally according to respective ranks at graduation. As a rule, all the graduates are sure of admission to the Government service.

The several services open to the graduates of the École Polytechnique are as follows:

1. *Land artillery, colonial artillery, or engineering corps*, in which they are accepted as "sublieutenant students of artillery," or of engineering, and are immediately placed in either the artillery school at Fontainebleau or the military engineering school at Versailles. Both these schools have a one-year specialized course in their respective subjects. The Versailles school also gives supplementary military and horsemanship training.

2. *Mines; bridges and roads; or naval engineering.*—On entering either of these services the polytechnic graduates assume the title of student engineers of mines, of bridges and roads, or of naval constructions, and pass, in this capacity, through a specialized course in one of the three schools of application maintained for this purpose. The course in the school of mines covers three years; in the school of bridges and roads, also three years; in the school of naval engineering, two years. After the completion of this course the students acquire the degrees of ordinary engineers of bridges and roads, or of mines, or subengineers of naval constructions. Those in the last category have to serve a practice term on the schoolship *Jeanne d'Arc.*

3. *Navy.*—On entering the naval service directly from the École Polytechnique the students receive the title of ship ensigns of the second class and are sent on board *Jeanne d'Arc*, where they complete their practice together with graduates ("aspirants") of the school of naval engineering.

4. *Manufacturing establishments conducted by the State.*—In this service the graduates of the École Polytechnique are placed directly in the tobacco plants or match factories with the degree of student engineers.

5. *The commissariat of the navy* accepts the graduates as commissaries of the third class; in order to become commissaries of the second class they must pass through a two-year course in the school of commissariat.

6. *The service of powders and saltpeters and the hydrographic service* are open to graduates of the polytechnique, admitting them at first for practice and later giving them permanent positions; for *telegraph service* a higher course of training in postal and telegraph subjects is provided.

Finally, graduates desiring to enter other civil services than the above enumerated have the advantage of the reputation attached to the institution.

Although St. Cyr, the great military school of France, is in no sense an adjunct of the École Polytechnique, many of the most distinguished officers of the French service have resorted to it for their mathematical training before entering the military school.

Fraternal societies.—An interesting and traditional characteristic of the École Polytechnique is the solidarity maintained among the graduates. This is manifested not only as a sentiment, but by the practical assistance and protection offered the younger or less fortunate graduates by those holding influential positions. For this purpose a fraternal society of graduates of the school is maintained, which assists members who meet with reverses, aids their destitute widows, and provides education for their children.

Modern methods of demonstration.—The higher technical schools of France have developed a system of demonstration by means of wall tables, charts, and luminous projections, that is in many respects the most advanced in the world. The École des Ponts et Chaussées possesses a unique collection of constructional plans, designs, etc., used to illustrate the instruction in the school; this collection is the joint work of professors of the various subjects and an eminent specialist, M. Coquillard, who has devoted to this task his exclusive activity for a long period of time.

For the last 20 years this school has also made extensive use of stereopticon projections, and has a rich collection of slides, especially those pertaining to reinforced concrete constructions. The use of cinematograph with specially prepared films of scientific subjects also received early recognition in this institution.[1]

ÉCOLES NATIONALES D'ARTS ET MÉTIERS.

The Écoles Nationales d'Arts et Métiers, situated, respectively, at Aix, Angers, and Chalons, are included in the class of secondary technical schools. These institutions were originally intended to provide the army of industry with directors, that is, managers and

[1] See article by Ch. Rabut in Revue Générale des Sciences, Mar., 1910, p. 127.

foremen of works, but they have developed beyond this stage, and it is claimed that they should be transferred to the class of higher technical schools. Admission to these institutions is determined by a competitive examination for which only those applicants are eligible who already possess the certificate showing the completion of the first cycle of the lycée course or its equivalent.

The three schools are noted for their elaborate equipment, the great competency of their teachers and directors, all of whom are selected by competitive examination, and the very rigorous character of the training throughout the three years' course. Graduates receive a special diploma, the brevet d'ingénieur des écoles nationales d'arts et métiers, which was created by a decree of 1907. Although these institutions do not give the same high degree of mathematical training as the École Centrale, the technical training is regarded as superior.

RECENT MOVEMENTS.

The higher technical schools of France have provided the State with trained experts for the public service, but on account of their specialized character and their location with few exceptions at Paris, they have not exercised a powerful influence in the industrial development of the country. Complaint is also made that in their isolation from the universities the technical schools lose the stimulating effects of scientific researches, for which only the universities have adequate equipment. A movement for correcting these defects was begun soon after the transformation of the former isolated faculties into organic universities in accordance with the law of July 10, 1896.

An important result of the new university régime was the multiplication of chairs for scientific studies and the equipment of laboratories and institutes in the provincial universities. At the University of Marseille a chair of industrial physics was established and another of industrial chemistry; at the University of Bordeaux a laboratory of chemistry instituted for the promotion of the resin industry; at Lyon chairs in chemistry equipped with laboratories for research in regard to local industries and agriculture. These are notable illustrations of a movement which spread to every university center of France, giving new direction to scientific research.

Through this extension of university activities, extreme specialization in the province of higher technical education in France has given place to the principle of coordination and philosophic unity. For the purpose of increasing this provision, a bill was introduced into the Senate during the present year, providing for the creation of separate faculties of applied science in all the universities. The motive for the bill was expressed in a ministerial circular which defined the new purposes which the universities must fulfill as follows:

> They must insure the renaissance of the national economic activity by means of the sciences, and take the direction of the vast movement for the revival of the chemical and physical industries which will of necessity follow peace.

It is interesting to note in this connection that the author of the bill, Dr. Goy, criticized severely the system of competitive examination by which admission is secured to the higher technical schools of France at the present time. For this system he recommended that candidates for admission to the proposed faculties of applied science should be required simply to present the bachelor's diploma and also one of the other special diplomas conferred by the university faculties of pure science. He said:

> In this way a student body would be formed having a high degree of scientific culture, in full sympathy with modern progress, and possessed of the force and energy necessary for directing industrial enterprises.

In addition to the institutions enumerated above should be mentioned engineering schools attached to universities. In most instances these form part of the faculties of science of the respective universities; the professors of the branches of science common to both the scientific and technical departments lecture in both. The technical students are matriculated as students of the faculty of science. The methods and contents of the technical instruction, however, are identical with those of independent technical schools. The degree conferred is that of engineer of the respective branches.

The following universities have engineering departments:

University of Grenoble, whose technical department is called Institut Polytechnique and is subdivided into several sections.

University of Toulouse has an electrical engineering school attached under the name of Institut Electrotechnique.

University of Marseille: École d'Electricité Industrielle de Marseille and École d'Ingénieurs de Marseille.

University of Nancy: Institut Electrotechnique et de Mechanique Appliquée de Nancy.

University of Lille: Institut Electrotechnique de Lille, and École de Hautes Etudes Industrielles et Commerciales.

University of Lyon: École Française de Tannerie, and École de Chimie Industrielle de Lyon.

Statistics of higher technical schools of France, 1913.

Institution.	Location.	Professors.	Students.	Budget, in francs.
École Polytechnique	Paris	37	440	.....
École Centrale des Arts et Manufactures	do	47	700	500,000
Conservatoire Nationale des Arts et Métiers	do	21	.....	1,000,000
École des Ponts et Chaussées	do	29	150	342,220
École Spéciale des Travaux Publics	do	150	1,600	.....
École Coloniale	do	37	126	.....
École Supérieure d'Electricité	do	18	126	.....
École Spéciale d'Architecture	do	21	95	140,000
École Nationale Supérieure des Mines	do	37	150	[1] 300,000
École Centrale Lyonnaise	Lyon	30	220	140,000
Institut Industriel du Nord de la France	Lille	[2] 20	.....	.....
École Nationale des Mines	St. Etienne	10	120	164,000

[1] State subvention. [2] Exclusive of lecturers.

GREAT BRITAIN.

INTRODUCTION.

The movement for technical education in Great Britain received its first impulse from the industrial changes that marked the opening of the eighteenth century, the result in great measure of the inventions of Watt and Whitney. In 1795 John Anderson, professor of natural philosophy in the University of Glasgow, bequeathed his estate to found Anderson University. The purpose intended was not immediately realized, but in 1800 Dr. George Birkbeck, professor of natural philosophy and chemistry in the new institution, started a system of popular lectures for mechanics. The lectures led to the formation of mechanics' institutes that have served as nuclei for technical institutions in several great centers of the Kingdom.

The spread of this idea in Great Britain was much slower than the same movement in continental countries, and on account of the local independence in respect to the control of education and the large part which is left to private enterprise and initiative, attention was first directed to provision for the special training of artisans and the establishment of technical schools relating to local industries. The present century, however, has been marked by great progress in the development of higher technical institutions and in the establishment of relations between them and the existing agencies for scientific research. At the present time the importance of this relation overshadows all other problems of higher education in the Kingdom. During the past year parliamentary provision was made for the formation of an advisory council in the board of education, charged with the interests of industrial and scientific research. In presenting the project to Parliament the president of the board explained the general attitude on this question, as follows:

> We must endeavor to secure that industry is closely associated with our scientific workers and promote a proper system of encouragement of research workers, especially in our universities. The fault in the past, no doubt, has been partly due to the remissness on the part of the Government in failing to create careers for scientific men. It has also, I think, been due partly to the universities, which have not realized how important it is that pure science ought to be utilized with applied science and brought into close contact with manufacturing interests. I think it was also partly due to the fact that the manufacturers themselves undervalued the importance of science in connection with their particular industries. It was partly due, too, to the fact that the ratepayers have been too niggardly in making provision in connection with their technical institutions and colleges.[1]

While the original efforts for the promotion of technical education were similar in the two divisions of the Kingdom, the development

[1] Parliamentary Debates, Vol. LXXI, No. 52.

of the work has been determined in each by different industrial and institutional conditions, and they should therefore be separately considered.

AGENCIES FOR HIGHER TECHNICAL EDUCATION IN ENGLAND.

In England provision for the higher orders of technical education has been made in the ancient universities and in technical schools or colleges that have developed up to the university standard. In the older universities the technical side is an outcome of provision for scientific research. The University of Cambridge was specially equipped in this respect by the establishment of the Cavendish laboratory of experimental physics, which was erected in 1872–1874 at an original cost of about $50,000. A few years after, the chemical laboratory of Cambridge was erected, at an original cost of $155,000. The resources of the two laboratories have been greatly extended, the latest additions having been supplied as recently as 1907.

The Cambridge laboratories were provided in the interests of medical science, and they were followed at the opening of the present century by the erection of new buildings for the medical school and the acceptance on the part of the university of a Government grant for the medical department. The provision for scientific research at this university was completed in 1894 by the erection of an engineering laboratory. This plant was started by an initial fund of $25,000, raised by public subscription and subsequently increased by private donations. Adjoining the laboratory are mechanical workshops with equipment for woodwork and iron work, the making of instruments, machinery, etc. Thus Cambridge, which had enjoyed great prestige as a center of mathematical instruction, was fully committed to the idea of including technical education within the university province.

The increasing recognition of the importance of technical education and its relation to scientific research was emphasized in 1912 by the acceptance on the part of Oxford University of a Government grant for the maintenance of the professorship of engineering science. By these measures the two oldest universities were linked up with the scheme of Government support for scientific and technical education.

The establishment of university colleges in the great centers of industry and population, and their gradual elevation to the university plane is the most notable event in the history of higher education in England during the last half century. These institutions were intended to meet local demands, and they all make provision for the various branches of engineering, technology, and agriculture, with the purpose of supplying experts for the conduct of industrial enterprises. The importance of this provision was signally recognized by a parliamentary grant in their interests, first allowed in 1889, and annually renewed down to the present time.

As a result of these successive efforts an elaborate system of technical education has developed in England which has culminated in technical faculties established at the universities, the Imperial College of Science and Technology at South Kensington, and provincial colleges and municipal technical institutes affiliated with the modern universities. The last two groups of institutions have maintained close relations with the general scheme of technical and industrial education in their respective communities, so that they exercise a powerful directive influence over the entire work.

TECHNICAL DEPARTMENTS OF THE ENGLISH UNIVERSITIES.

The universities which have made provision for technical education are maintained in part by a Government grant and are consequently required to make an annual report to the board of education. For 1913–14 the total number of their students in all departments was 7,344. Of this number, England claimed 6,551, of whom 23 per cent were in the engineering departments. The remaining 793 students were in the Welsh institutions, and of these nearly 10 per cent were in the engineering departments. The appropriations by Parliament for these institutions amounted in the same year to £174,000 ($845,640), of which 85.6 per cent went to those of England. It is impossible to indicate what proportion of the fund is expended directly for engineering purposes, but in general it may be said that the entire amount is applied to modern education. The following table presents salient particulars respecting the technical departments here considered:

Students in technical departments of universities.

Institutions.	Total students in all departments.	Students in the technical departments.					Percentage of technical students.
		Students taking undergraduate courses.			Taking post-graduate courses.	Total	
		Degree.	Diploma.	Other courses.			
ENGLAND.							
Birmingham University	867	152	12	13	8	185	21.00
Bristol University, Merchant Venturers' Technical College	69	55	14	.....	.....	69	100.00
Durham University, Armstrong College	543	129	31	5	1	176	32.41
Leeds University	663	48	40	56	4	148	22.32
Liverpool University	861	60	51	3	8	122	14.16
Manchester University	1,014	51	11	5	3	70	6.90
Manchester Municipal School of Technology	285	114	141	13	17	285	100.00
Sheffield University	349	41	40	36	1	118	33.81
London University:							
University College	841	75	51	17	1	144	17.12
Kings College	464	58	42	1	6	107	23.00
East London College	205	19	1	18	1	39	19.00
Nottingham University College	263	11	29	.....	1	41	15.58
Southampton University College	127	6	12	.....	1	19	14.96
Total, England	6,551	829	475	167	52	1,523	23.25
WALES.							
Bangor University College	296	.....	.....	6	.....	6	2.00
Cardiff University College	497	21	51	.....	.....	72	14.48
Total, Wales	793	21	51	6	.....	78	9.84

In addition to the universities comprised in the above table, the department of engineering science of Oxford University, which receives a small annual grant (£350 in 1913–14) registered 21 students. The students of the engineering department of Cambridge University are not separately given.

THE IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON.

The Imperial College of Science and Technology received its charter in July, 1907. As stated in the charter, it was intended "to give the highest specialized instruction and to provide the fullest equipment for the most advanced training and research in various branches of science, especially in its application to industry." For the accomplishment of these purposes three existing colleges were federated, namely, the Royal College of Science, the Royal School of Mines, and the City and Guilds (Engineering) College.

The Royal College of Science and Royal School of Mines were formerly Government colleges, but when the federation took place they were handed over to the governing body of the Imperial College of Science and Technology which consists of 40 members; the present chairman is the Most Hon. the Marquis of Crewe, K. G., and the rector is Sir Alfred Keogh, K. C. B., LL. D. Sir Alfred Keogh stands in a similar position to the federation as the vice chancellor to a university; his work is mainly coordinating and organizing.

Until 1907 the City and Guilds (Engineering) College was entirely independent, was known by the name of the "Central Technical College," and belonged to the City and Guilds of London Institute, by whom its affairs were managed. The City and Guilds (Engineering) College still belongs to the institute, which, instead of managing through a committee of its own, has delegated its powers to what is known as the delegacy of the City and Guilds (Engineering) College. This delegacy, which was appointed at the time of the federation, consists of eight representatives of the City and Guilds College, eight from the governing body of the Imperial College of Science and Technology, and three representatives from the Goldsmiths' Co. All the affairs of the college are managed by this delegacy, to whom the entire staff (teaching and otherwise) are responsible. The chairman of the delegacy is Sir John Wolfe Barry, K. C. B., F. R. S., and the dean of the City and Guilds College is Prof. W. E. Dalby, F. R. S.

When the federation was brought into existence, the needs of the engineering college were especially considered, and an extension has been built which has practically doubled its capacity. This extension was erected by funds generously provided by the Goldsmiths' Co.[1]

Entrance requirements.—The entrance requirements of the separate colleges are determined according to their individual scope and the

[1] Cited from statement by W. E. Dalby, dean of the engineering college.

interests or purposes of candidates for admission. They are all, however, marked by the same liberal spirit. In general, the colleges receive young men, not under 17 years of age, who have had a good secondary education, and excuse them from the first, second, or third year course according to the standard which they have attained when they present themselves. The decision in this respect is made by the professors particularly concerned.

The conditions for the admission of research students are as follows:

A candidate desirous of undertaking original research must have completed an associateship course in one of the departments of the Imperial College, viz, the Royal College of Science, the Royal School of Mines, or the City and Guilds (Engineering) College, or an equivalent course of study elsewhere, and must satisfy the rector and professors as to his qualifications for extended study. The subject of research will require the approval of the professor of the department in which it is to be carried out.

The absence of uniform, rigid entrance requirements accords with the conduct of studies within the federated colleges. The purpose has been to keep them free from academic traditions and the restrictions of fixed syllabi. The general system of classification makes adequate provision for students of different degrees of advancement and having different ends in view.

The charter of the Imperial College provided for the coordination of its work with that of the University of London, and in 1908 the college was admitted as a school of the university in the faculties of science and engineering. The ultimate relation of the two great institutions became, therefore, a matter of consideration on the part of the royal commission on university education in London, appointed in 1910. The opinion was strongly expressed by the commission that, by closer relations with the University of London, the standard of admission to the Imperial College would be raised and thus the college would make a substantial gain. In response to this suggestion it was explained that a movement had already begun on the part of committees of the governing body of the Imperial College to effect this change. It had even been proposed that the first two years' courses in the college of mining and the college of science should be abandoned. Advanced standards have already been secured in the case of the engineering college, to which students are now admitted by competitive examination. This does not preclude varied degrees of previous attainment, but it insures the choice of the most promising in each particular line of study, a measure necessitated by the excess of applicants for admission.

Fees.—A fee of £1 ($5) is required of all candidates for admission to associateship courses and must be forwarded with the form of application. The fees for full-time associateship courses, payable in advance, are as follows:

Imperial College, Royal College of Science, £36 10s. per session.
Imperial College, Royal School of Mines, £45 10s. per session.
Imperial College, City and Guilds (Engineering) College, £38 10s. per session.

The fees for research work and special advanced study vary according to the nature of the course selected. Examinations are held at the end of each course of instruction and at such other periods as may be deemed necessary.

Diplomas.—The following diplomas are awarded to students who satisfactorily complete the appropriate organized course of study and pass the necessary examinations:

(*a*) The Diploma of Membership of the Imperial College of Science and Technology (D. I. C.).
(*b*) The Diploma of Associateship of the Royal College of Science (A. R. C. S.).
(*c*) The Diploma of Associateship of the Royal School of Mines (A. R. S. M.).
(*d*) The Diploma of Associateship of the City and Guilds of London Institute (A. C. G. I.).

Courses of instruction.—The courses of instruction fall mainly under the following heads:

(1) Diploma Courses. Organized courses of instruction extending over three or four years leading to the diplomas of associateship of the Royal College of Science, the Royal School of Mines, and the City and Guilds of London Institute.

(2) Special or Partial Courses. Short courses of lectures, with or without laboratory work, of an advanced character dealing with special branches of pure and applied science suitable for those who have graduated or are already engaged in some scientific industrial occupation.

(3) Advanced Specialized Courses. Research work and specially arranged courses of study in advanced science or technology extending over one or more complete years leading to the diploma of the Imperial College.

The scope of each one of the federated colleges is outlined in the calendar as follows:

Royal College of Science affords complete courses of training, extending over three years, in mathematics, mechanics, physics, chemistry, botany (including the first portions of the Imperial College diploma courses in plant physiology and pathology, and the technology of woods and fibers), zoology, and geology, which may be regarded as complete in themselves or as preliminary to more advanced work in the applications of the subjects in question to industrial problems.

The Imperial College—Royal School of Mines affords complete specialized courses of training, extending over four years, designed adequately to equip a student who desires to follow the profession of a mining, a metallurgical, or an oil engineer.

The Imperial College—City and Guilds (Engineering) College affords complete courses of training, extending over three years, in engineering, arranged to suit the requirements of those preparing for engineering as a profession, or who desire to acquaint themselves with the scientific principles underlying any particular branch of engineering.

In addition, the Imperial College offers special facilities for work of a more advanced character in all the branches of science previously referred to. The advanced student may engage in research work, or attend full-time organized courses of a more advanced character than those forming the normal courses of the three institutions which are integral parts of the Imperial College, or he may attend the college as a part-time student for the purpose of taking up one of the special lecture courses, with or without laboratory work, or a specially arranged course of study whether in pure science or in the application of science to industry.

Such courses include (*a*) Railway engineering, (*b*) Structural engineering, (*c*) Hydraulic engineering, (*d*) Surveying and geology, (*e*) Electrical machinery and transformers, (*f*) Design and erection of chemical plant, (*g*) Fuel and refractory materials,

(h) Technology of woods and fibers, (i) Economic botany, (j) Plant physiology and pathology, (k) Biochemistry, (l) Economic entomology, (m) Comparative pathology, etc.

Equipment for practical work.—The equipment of the department of municipal and sanitary engineering comprises a "commodious drawing office, laboratory, and lecture room, and a well-arranged and fully-equipped sanitary engineers' workshop, provided with modern appliances."

Standard surveying instruments, as well as special appliances, are available for field work.

Methods of water supply and sewerage are illustrated by collections of models and drawings showing every phase of the most modern systems.

Appliances are provided for testing the suitability and efficiency of materials used in drainage, sewerage, and waterworks construction; for testing the strength, watertightness, and absorption of stoneware and other pipes, and the joints used in connection with them; and for testing the efficiency of filters and the character of water supply.

There is a collection of the various forms of automatic and ordinary water taps, and of various types of valves, hydrants, water meters, including a Deacon waste-water meter and other waste-preventing arrangements, so arranged that their principles and methods of construction can be readily studied and their efficiency tested. A set of full-sized working examples is arranged and fixed to illustrate the best methods of supplying hot water for domestic and other purposes. Valuable tests and experiments can be carried out bearing upon water circulation, domestic boilers, and the prevention of explosions and other accidents. Means are available for testing the efficiency of the materials used for pipes, and of the results of coating hot and cold water, steam and other pipes to prevent rust, loss of heat, and damage by frost.

Appliances are provided for illustrating in a practical way the principle of heating and ventilation as applied to buildings. The school building itself is a model of modern sanitary and efficient construction.

In connection with the study of road and street construction there is a collection of materials used for the various classes of work, together with drawings, specifications, and particulars as to the cost of construction and maintenance of roads and streets.

The Imperial College realizes more perfectly perhaps than any other technical institution of high grade, the principle of freedom of instruction and freedom in learning, but this principle has been maintained without the sacrifice either of thoroughness or high standards, and it has been made possible by the high order of scientific and technical ability characterizing the officers and teaching staff throughout the entire history of the three constituent institutions. The constant relation maintained between the results of scientific research and their practical applications is illustrated by the system of training in the mining school which has been developed in advice with persons actually engaged in the mining industry; a board of mining and metallurgy was recently constituted to advise from time to time as to the course of the Imperial College, and also to examine, as might be deemed advisable, the system of education

in the college to determine whether in its details it was likely to prepare students for the practical duties of the mining profession. This is regarded as a very essential feature of the organization, and it is intended that it shall run through every branch of the work of the Imperial College. The term "imperial" indicates the purpose to make this college a center of advanced study which may draw students from all the universities of the Empire, a purpose which is furthered by the very liberal provision of scholarships, and also by the unsurpassed equipment of the Imperial College for technical and scientific studies, the laboratories and buildings, with the available land for the institution representing at the present time a capital value exceeding $5,000,000.

The plans for making London a leading center for liberal and technical education which occupied the serious attention of the Government on the eve of the European war, will doubtless be revived in the near future as one result of the enormous impetus given to the problems of higher education by that event, and in this revival the ultimate relation between the two central institutions will again be the subject of profound consideration. The tendency in Great Britain has been to bring the highest orders of training within the university province, and this view was sustained by the commission on university education in London already referred to. In this connection their report says:

> Weight was laid in the evidence of the Imperial College upon the existence of a technical hochschule at Charlottenburg independent of the University of Berlin as furnishing support for the views of the governing body of the Imperial College. * * * The conditions in Germany are, however, quite different from those in England. The scope of the Imperial College is much wider than that of Charlottenburg, for there are no biological departments in the hochschule. The University of Berlin contains no departments of engineering such as those founded in connection with the University of London many years before the establishment of the Imperial College. The universities of Germany were at first greatly opposed to including a technological faculty, and many of them were placed in towns quite unsuited for work of this kind; yet many Germans of standing in the university world, notably Paulsen and Felix Klein, have viewed with regret the attitude the universities assumed. The reverse is the case not only in the University of London, but in all the universities of this country. Oxford has a department of forestry; Cambridge one for agriculture; both have departments of engineering; and, as we have shown, the history and circumstances of the modern universities have naturally led them to lay stress on the preparation for professional life of all kinds. But the practice of combining technology with other studies within the university is not confined to England. It holds equally in Scotland, Ireland, and Wales, and it holds also throughout the universities of the British dominions. * * * If, however, it is contended that the Imperial College is different from all these, because it ought in time, whatever may now be its practice, to devote itself solely to advanced work and research, to be a kind of super-university, for which the other universities of the Empire will prepare, then the Charlottenburg hochschule can not be quoted in support, for the main work of that institution is undergraduate, and its standard of admission the same as that of the German universities.[1]

[1] Royal Commission on University Education in London, Final Report, London, 1913, pp. 85-87.

MANCHESTER MUNICIPAL SCHOOL OF TECHNOLOGY.

Stages of development.—The Manchester Municipal School of Technology, developed from the Mechanics Institution founded in that city in 1824, is of university rank and at present recognized as one of the leading technical schools of the world. The course of this development is typical of what has taken place in the case of several other similar institutions in Great Britain. Established as a Mechanics Institution, it occupied for over 13 years the first building expressly designed for such an institution. In 1857 it was removed to larger premises, which were secured mainly by popular subscriptions. In 1882 the institution received contributions toward its maintenance from the City and Guilds of London Institute, which was organized to promote technical education throughout the Kingdom. At the same time the local contributions to the Manchester Institute were greatly increased, and the name was changed to Manchester Technical School. In 1887 this school became a beneficiary under the terms of the will of Sir Joseph Whitworth, who left some £300,000 ($1,500,000) to legatees for the promotion of technical and art instruction. It was proposed to devote this fund to an institution that should include a technical school, a school of art, and a museum, and to bear the name of Whitworth Institute. Arrangements were made with the governors of the technical school for the consummation of this purpose, which was furthered by the donation of the profits accruing from the Manchester Jubilee Exhibition.

Meanwhile, by the passage of the technical instruction acts of 1889 and 1900, the Manchester city council was empowered to aid technical education out of the rates (property tax), and for this purpose additional taxes amounting to £15,000 a year were also placed at its disposal. In view of the enormous increase of the funds which the city council was prepared to devote to the technical school, it was decided that the council should have full control of the institution. This decision was concurred in by the governors of the Whitworth Institute, and in March, 1892, the technical school, with all its properties, including a large estate that had been offered as a site by the legatees of Sir Joseph Whitworth, was transferred to the municipal corporation. As a consequence of this transfer the school assumed the title of the Municipal School of Technology and entered upon a period of rapid expansion.

In 1905 the school of technology was associated with the University of Manchester, which established a faculty of technology and recognized the principal of the school as dean and the heads of the several departments as professors of the university.

Present status.—In 1912 the school of technology was officially recognized as a college of university rank and included among the higher institutions in Great Britain which received grants from the board of education. The site, buildings, and equipment of the school of technology are now valued at £380,000. The annual cost of maintaining the school is approximately £50,000.

Since ascending to the university plane, the teaching and research work of the school of technology have been brought into closer relation with the industries of the district; and the demand for graduates exceeds the supply and is constantly growing.

Organization of courses.—The work of this municipal institution is organized in the interests of three classes of students. Those who wish to complete a full course of technical training, leading to the degree of bachelor of scientific technology; students who contemplate a more limited course of training; and graduate students either from the Manchester school or from universities. Students entering for the degree courses are required to pass the matriculation examination and a second test, the intermediate examination, which may be deferred until at least a year before entering for the diploma examination. Certificate courses are also provided for students, which do not require the same entrance examination as the degree courses.

Degree courses.—The division of the Manchester School of Technology which is comparable with the higher technical schools previously considered is comprised in the degree courses. Candidates for admission to this division must pass the matriculation examination which covers the following subjects:

English language and literature, English history, mathematics, and three of the following subjects, one of which must be a language, Greek, Latin, French, German, some other language approved by the board, either mechanics or physics, chemistry, geography (physical, political, and commercial), either natural history (plants and animals) or botany.

Credit is also given for alternative papers of a higher standard which are taken according to specified conditions.

The degree courses extend over three years from matriculation, and lead to the degree of bachelor of technical science (B. Sc. Tech.).

The subjects of these courses are:

Mechanical engineering.
Electrical engineering.
Sanitary engineering.
Applied chemistry:
(*a*) General chemical technology.
(*b*) Chemistry of textiles (bleaching, dyeing, printing, and finishing).
(*c*) Paper manufacture.
(*d*) Metallurgy and assaying.
(*e*) Chemical technology of brewing.
(*f*) Electrochemistry
Textile industries.
Architecture.
Printing and photographic technology.

In the conduct of the degree courses, great importance is attached to the practical exercises. In the course of mechanical engineering, which is taken as typical, the relative proportion of time assigned to theoretical and practical instruction is shown in the following table and diagram:

Time assigned to theoretical and practical subjects

Periods.		Hours per week	
		Theoretical study.	Practical exercises.
First year	First term	21	11
	Second term	24	8
	Third term	25	7
Second year	First term	23	9
	Second term	23	9
	Third term	20	12
Third year	First term	14	16
	Second term	14	17
	Third term	13	18

These relations are presented in graphic form in the following diagram:

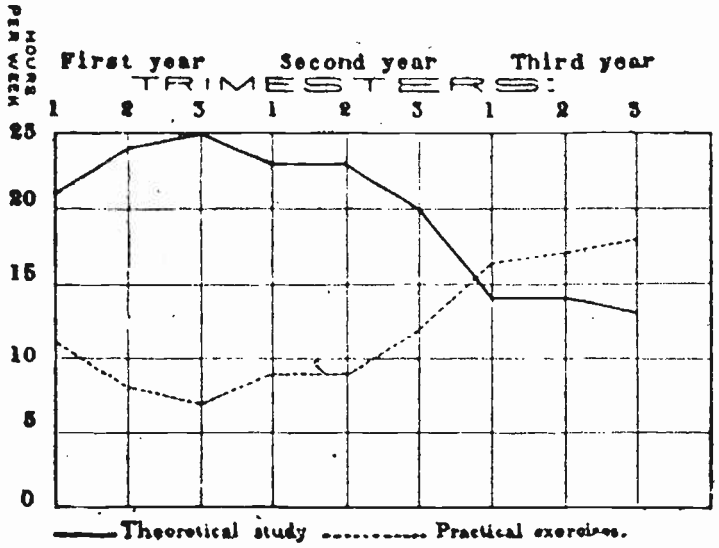
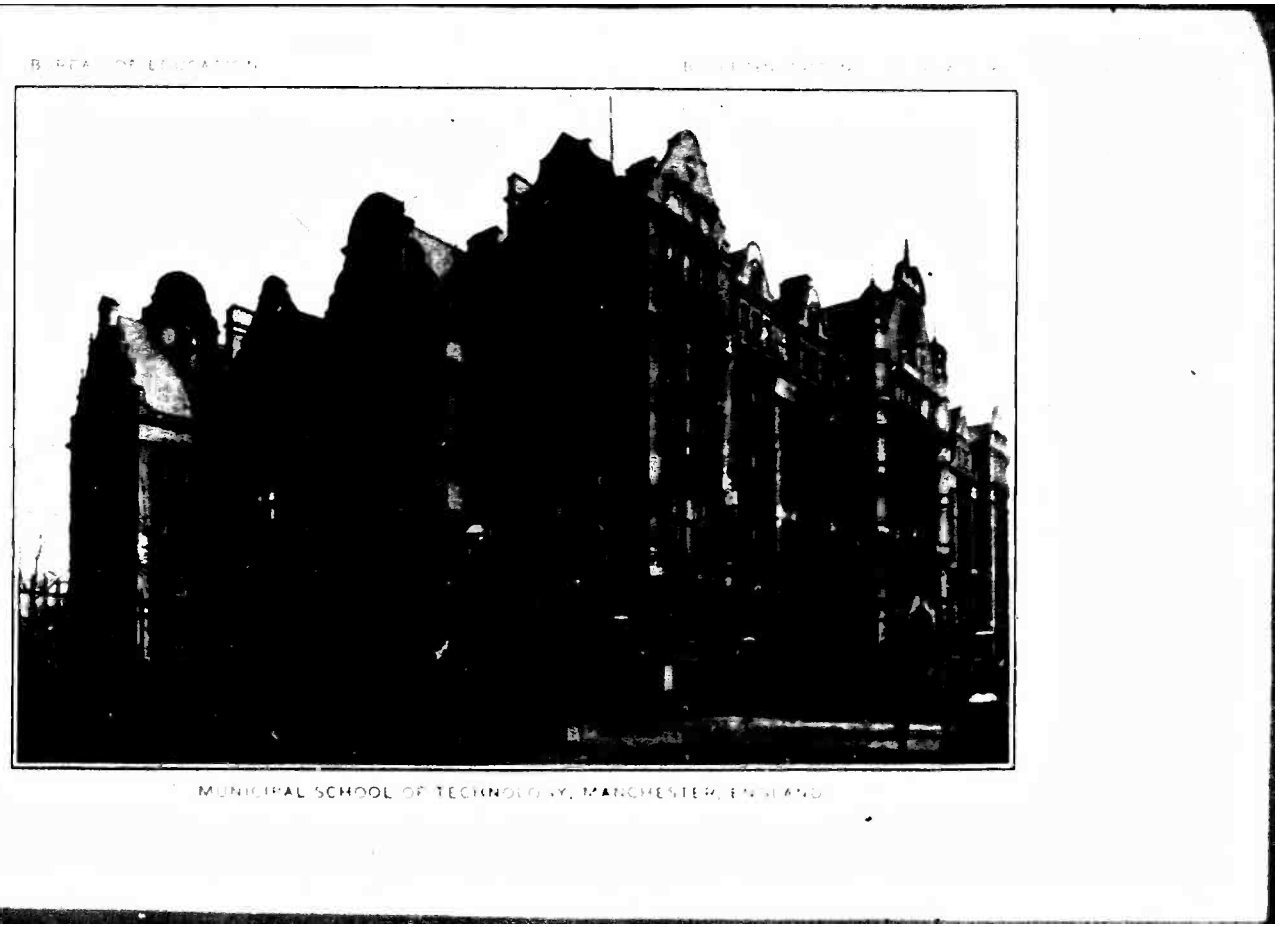


DIAGRAM 3.—Distribution of time between theoretical and practical instruction at Manchester Technical School, Department of Mechanical Engineering.

Special courses are also arranged for students who possess the necessary preliminary knowledge, but are unable to comply with the usual attendance regulations.



MUNICIPAL SCHOOL OF TECHNOLOGY, MANCHESTER, ENGLAND

The following table gives particulars of the numbers of students attending university courses in the school of technology during the academic year 1913–14:

Students in university courses of the Manchester School of Technology.

Courses.	Living in Manchester.	Living outside Manchester.	Total students.
Research	16	5	21
Degree courses	90	24	114
Certificate courses	87	55	142
Special courses	33	36	69
Total	226	110	336

In this table the students shown as being engaged upon research are for the most part graduates of Manchester University who intend to embody the results of their researches in theses which they will submit to the examiners for the higher degree of master of technical science (M. Sc. Tech.). Among the research students there are also some graduates of other universities who are required to carry out research work for two years in the school of technology before submitting a thesis for the M. Sc. Tech. degree. Persons who are not graduates of this or any other approved university who have conducted research work approved by the faculty of technology during a period of three years may also submit theses for the M. Sc. Tech. degree. Finally, some few of the research students are not intending to proceed to a degree in this university. Among these latter are included advanced students or teachers in other universities who are pursuing their researches for a time in the school of technology on account of the special facilities which it affords.

Certificate courses are also provided to meet the needs of students whose previous education is not sufficient to enable them to pass a matriculation examination, but who for many reasons are likely to profit by the privilege of attending a university course. With the improved provision for secondary education the need for certificate, alternative to degree courses, is rapidly disappearing so far as students proceeding direct from school to college are concerned. Steps have therefore been taken to restrict the certificate courses to students who have had at least one year's full-time industrial experience after leaving school. The certificate courses, with a single exception, are the same in respect to subject matter as the degree courses; they provide, however, special arrangements relating to students who may desire to proceed to a degree examination. The special courses are two years' certificate courses provided in architecture and photographic technology.

From the official announcements it appears that:

Schemes are in operation whereby the teaching in the school of technology is coordinated with the practical training in various industrial works, and these schemes apply not only to students who are employed in industry during the greater part of their time and attend part-time classes also at the school of technology, but also to

the university students who, during the three or four years which they devote to their degree course, spend their long vacation in works, to which they return as "college apprentices" to complete their training when their whole-time college course is finished.

It is not, however, only in regard to the training of engineers, chemists, and other technologists that the work of the school of technology is coordinated with the industries of the Manchester district. The school of technology is now formally asked to undertake not merely routine tests, but special researches on behalf of firms in this district. Moreover, in some instances the school of technology has cooperated with some local technical or professional society in the conduct of experimental researches extending over a considerable period of time. As an instance of this may be mentioned the experiments on cutting tools originally undertaken by the late Prof. Nicolson in conjunction with the Manchester Association of Engineers and now continued by Mr. Dempster Smith.

A further instance of the growing interest which important firms take in the work of the school of technology is afforded by the fact that when proposals were recently made for the erection of some new internal combustion research laboratories promises were received from local engineering firms to give the school of technology the use of engines worth at least £3,000.

During the past year the laboratories and workshops of the school of technology have been largely occupied with Government work. Indeed, the school of technology through its engineering, chemistry, and textile departments may claim to have rendered important service to the country and its allies on the engineering, chemical, and textile sides of the war, as well as in the supply of antiseptics and anæsthetics.

The high standard of the scientific work of the Manchester school is shown by the Record of Investigations conducted by members of the staff and by advanced students. This publication, which has just reached its eighth volume, covers, it is said—

researches carried out since the year 1900 in all departments of the school, including pure and applied mathematics, mechanical engineering, physics, and electrical engineering, pure and applied chemistry and metallurgy, the science and practice of sanitation and building, textile manufacture, and the photographic and printing industries.

For investigations in all the departments named, the institution is admirably equipped and has the advantage of assistance from leading manufacturers. Extensive increase of the laboratories had been planned before the war, and the work has not been entirely hindered by that event. In particular, attention is called to the—

new laboratories for advanced training and research in the subject of coal-tar chemistry in its bearing upon the dye-stuff industry, which have been opened under the charge of Prof. A. G. Green, of the University of Leeds, with the help and advice of Dr. E. Knecht, the professor of chemical technology, thus giving full opportunity, not only for the efficient training of chemists for the growing demands of the organic chemical industries, but for the establishment of a school of research for the chemistry of dyes and allied substances employed in industrial chemistry.

In regard to provision for laboratory research and the industrial applications of the results thus obtained the Manchester technical school ranks with the highest in Europe.

TECHNICAL COLLEGES OF SCOTLAND.

Glasgow and Edinburgh are centers of technical education in which the gradual development up to the highest order of institutions has followed the same course as that noted in the case of English centers. The Royal Technical College, affiliated to the University of Glasgow, and the Heriot-Watt College, coordinated with the University of Edinburgh, represent the highest provision for technical education in Scotland. Both institutions were at first intended to provide instruction in evening classes for clerks and mechanics, and they were eventually linked up with the system of examinations carried on by the science and art department. At present these institutions maintain close relation with the continuation schools and evening classes established by the school boards, and also provide professional courses for engineers, expert chemists, etc., in accordance with university requirements and standards.

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

The Royal Technical College, more commonly known as the Glasgow and West of Scotland Technical College, is the center for the western division of Scotland, comprising nine counties. All the science classes of this division are affiliated with the technical college, to which their students are admitted by the school certificate. This college was founded in 1796 on the bequest given by Prof. John Anderson, to whom reference has previously been made. Its present status is briefly set forth in the following official statement:

In 1913 the technical college was affiliated to the University of Glasgow. Its day work is of university standard. The major part of its evening work is of similar standard, but it also conducts a number of evening trade classes.

Day students must have attained a minimum age of 17 years, or have passed the preliminary examination of the Scottish universities for graduation in science. This examination, or a recognized equivalent, is obligatory on all students who propose to proceed to a degree in applied science, and comprises (1) mathematics, (2) English, and (3) either two languages, or one language and dynamics. Occasional students or students who intend to proceed to the college diploma only are admitted without examination if they satisfy the authorities that they are qualified to enter upon the course of study they propose. Their qualifications must include a knowledge of mathematics at least sufficient to enable them to enter the lowest classes in mathematics.

The diploma of the college is granted in the following subjects, which indicate its main departments: Civil engineering, mechanical engineering, electrical engineering, mining, naval architecture, chemistry, metallurgy, building, textile manufacture, dyeing, and sugar manufacture. In chemistry and metallurgy the course is four years of nine months each. In engineering the course is not less than three years of the six winter months. All engineering students are expected to spend the summers in practical work, usually as a part of their formal apprenticeship in engineering, except for one summer in the case of civil engineers and mining engineers, which is given to college work in surveying.

It may be said that, in general, the courses of study are divided in approximately equal proportions between theoretical and practical work, the mornings being given to lectures and the afternoons to the laboratories or to drawing. In the later years of the courses in chemistry and metallurgy more time is given to laboratory work.

Students make their own arrangements with employers with reference to admission to a works, but in the normal conditions of industry they have usually no difficulty in doing this. The variety of the industries in the west of Scotland, the very varied requirements of students, and the characteristics of particular industrial works interfere with any organised scheme.[1]

The college registered 600 day pupils in 1913, of whom more than half were giving their whole time to college work to which they were admitted on full university standard. The other half of the student body comprised about 150 graduate students who were attending for special courses. All the day students were doing work of university standard with the exception of one little group, viz, that of bakers. The presence of this small body of students illustrates in a striking manner the practical bearings of the institution. It is the result of a movement on the part of the master bakers, who subscribed $20,000 to equip rooms for this particular subject. One of the associates in chemistry, who had also a practical knowledge of bakery, was installed as a lecturer. The students number 10 or 12, nearly all sons of bakers, who are giving their time to this work with the expectation of succeeding their fathers in the business. The "school of bakery and confectionery" promises to remain a distinctive feature of the college, because the bakers of Scotland have made sacrifices in its interests. At present the master bakers of Glasgow subscribe $500 a year for its support and provide all the material used in the school. The course of study, which extends over two years, includes the following subjects: Bakehouse and shop bookkeeping; practical breadmaking; practical confectionery; icing and piping; and laboratory work. This practical work is supplemented by a comprehensive course of lectures dealing exhaustively with the materials and the processes that relate to the baker's art

HERIOT-WATT COLLEGE, EDINBURGH.

The Heriot-Watt College was founded in 1821 under the name of the School of Arts, by the cooperation of a number of prominent men of Edinburgh. Its object, as indicated in the prospectus, was "the better education of the mechanics of Edinburgh in such branches of physical science as are of practical application in their several trades." The name of the school was later changed to the Watt Institution, as the result of agreement with a committee which had raised a fund as a memorial to James Watt; and eventually under the provisions of a scheme obtained from the educational endowments commission, the Watt Institution was combined with

[1] Cited from statement by the director, Dr. H. F. Stockdale.

that of George Heriot's hospital and was thenceforth known as the Heriot-Watt College. Although essentially an institution for technical education, it comprises commercial classes and a section for literature, music, and languages. Hence with a high order of technical instruction, leading to a variety of professional callings and trades, provision is made for the practical educational needs of the community. The former purpose alone is here considered.

The technical division of the college grew steadily in strength and effectiveness, and finally was brought into close relations with the University of Edinburgh. The technical instruction is given in day classes, special classes, and evening classes. The scope and standards of the work are indicated by the following statements:

In 1901 an arrangement was made between the University of Edinburgh and the Heriot-Watt College with a view to securing mutual cooperation in the training of engineers; a joint advisory committee, representative of the university and George Heriot's trust, was appointed; and it was arranged that one of the professors of the Heriot-Watt College should also be a member of the examining board for the engineering degree at the university. Under this arrangement an exchange of students took place between the two institutions—diploma students of the Heriot-Watt College receiving part of their training at the university, and degree students of the university receiving part of their instruction at the Heriot-Watt College. At the same time, a course of three years was laid down for the college diploma in engineering, and a course of four years for the diploma in technical chemistry.

The latest arrangement with the University of Edinburgh enables students of the Heriot-Watt College to obtain degrees in the three departments of civil, mechanical, and electrical engineering. The first year's training in all three branches is received entirely within the university. In the second year, when specialization begins, the studies are pursued partly at the university and partly at the college. In the third year, when specialization is carried to its completion, the greater part of the training in electrical and mechanical engineering is given at the Heriot-Watt College, while, as heretofore, the civil engineering students receive their third-year course of training at the university. It is further provided that the classes held in the day college shall be recognized by the University of Edinburgh, so that students can proceed to take degrees in engineering and in chemistry by passing all the necessary university examinations and attending certain additional classes in the university.

The arrangement with the university also enables university students to specialize in the departments of engineering maintained by the Heriot-Watt College; hence students of engineering registered in the Heriot-Watt College or in the University of Edinburgh may

become candidates for both the diploma of the college and the university degree of B. Sc.

All students in the day classes of the Heriot-Watt College are admitted by examination, or proofs of equivalent attainments. Those who enter for a diploma course must pass an examination covering the following subjects:

(a) English and mathematics. These two subjects must be taken by all candidates.

(b) Any two selected from the following: Experimental science, French, German, Spanish, Italian, Latin, Greek. The governors may accept a language other than those named, but a candidate must give three months' notice of his wish to be examined in such language.

All the subjects professed by the candidates must be taken at one time, and the examination must be passed as a whole. The preliminary examination will be held twice a year,—in April and in September.

Candidates who hold the leaving certificate of Scotch secondary schools, or equivalent proofs of attainment, are excused from this examination.

The subjects of the final examination for the diploma conferred by the college are grouped as follows:

Group I. Mechanical Engineering.—Engineering, higher standard; mathematics, higher standard.

Group II. Electrical Engineering.—Electricity, higher standard; electrical engineering, higher standard; mathematics, higher standard; mechanical engineering, pass.

Group III. Chemistry.—Pure chemistry, higher standard; one branch of applied chemistry, higher standard, such as gas manufacture; or some department of applied analytical chemistry; or physics, higher standard; or physical chemistry; or electrical engineering, higher standard.

Group IV. Brewing.—Theory and practice of brewing, higher standard; pure and applied mycology and bacteriology, pass; enzymology, pass; chemistry, pass; engineering, pass.

Group V. Brewers' and Distillers' Analysis.—Theory and practice of brewing and distilling, pass; pure and applied mycology and bacteriology, higher standard; enzymology, higher standard; chemistry, higher standard; analytical chemistry and mycology and enzymology, higher standard.

Group VI. Mining Engineering.—Geology and mineralogy (examination held at the end of the second year); coal mining, higher standard; metal mining, higher standard; mine surveying, higher standard.

Two degrees of science in engineering are conferred by the university, viz, bachelor of science in engineering and doctor of science in engineering. The requirements for these degrees are determined by a joint advisory committee on engineering studies consisting of the professors of mathematics, natural philosophy, chemistry, and engineering, and the dean of the faculty of science, together with representatives of the governors of George Heriot's trust.

The facilities for practical training available for the students of engineering and chemistry in Heriot-Watt College include not only the extensive laboratories and workshops of the college itself, but

also the laboratories of the university. Recent additions to the equipment include an elaborate range of new chemistry laboratories, extensive laboratories equipped for the study of technical mycology, and a mine-rescue station attached to the mining department.

Arrangements have been made with leading firms of engineers in Edinburgh and elsewhere by which students of the college are allowed to begin their apprenticeship at the end of the second winter's session, returning to the college the following autumn to complete their third session. As a result of these arrangements, if a student on entering the college puts down his name as an apprentice with one of the firms, he can obtain his whole training, both theoretical and practical, as a mechanical or electrical engineer in from five to six years. Students of exceptional ability also have the chance of securing bursaries which greatly reduce the cost of tuition. The annual fees for day classes vary according to the number of lectures and the stage of advancement in the course. Composition fees for the complete winter courses in mechanical and electrical engineering and chemistry range from £12 12s. to £15 5s., not including the matriculation fee of 5s. The fee for the summer workshop courses is £2 2s., and for the summer laboratory course £3 3s. The arrangements with engineering firms referred to make it possible for a student to secure his training at the college for three complete sessions, plus the premium for apprenticeship, for a sum varying from £120 ($600) to £200 ($1,000) according to the firm chosen for the apprenticeship.

Students who pass the university preliminary examination have the advantage of the provision for the payment of fees by the Carnegie trust, under the same conditions as those which apply to the university students.

IRELAND.

The University of Dublin, Ireland, established a school of engineering in 1842 for the purpose of affording to such students as intend becoming civil engineers systematic instruction in the branches of knowledge relating to their profession.

Such students are required to register as members of Trinity College and subject to its regular discipline.

The professional course in engineering covers three years; the instruction is conducted by means of lectures, laboratory and field work. An optional fourth year's course has been established for students wishing to make a special study of electrical engineering.

The university confers a certificate in engineering upon students who complete the full three years' course and pass the final examination.

A student who has not only completed his course in the engineering school, but has also completed the first two years in the course in arts and passed the final freshman examination (Littlego), is entitled to the license in engineering granted by the university. A student who has not only completed his course in the engineering school, but also graduated in arts, is entitled to proceed to the degree of bachelor in engineering. A bachelor in engineering who has been actually engaged upon engineering works for a period of three years is entitled to proceed to the degree of master in engineering.

A diploma in electrical engineering is conferred upon those students who take the optional fourth year.

SWITZERLAND.

POLYTECHNIC SCHOOL, ZURICH.

Organization.—The Polytechnic School is the only educational institution in Switzerland under the control of the Federal Government, and its organization is therefore a matter of unusual interest. The supreme executive and directive authority is vested in the Federal council, whose decisions respecting the affairs of the institution are based upon recommendations submitted by the minister of the interior.

For the immediate administration of the Polytechnic School a body called "Swiss school council" is appointed by the Federal council. The Federal council, however, reserves for its own decision all important matters. It appoints, transfers, and retires professors and the auxiliary teaching forces of the school; issues rules and regulations of ordinary importance, to be observed by the institution, the fundamental statutory regulations being decided by the Federal Assembly. The Federal council also controls the finances of the school and examines the annual reports submitted by the school council. All gifts and bequests offered to the institution must be approved by the Federal council before they are accepted, and the expenditure of general funds of the school is supervised by that body. The school council is, however, freely consulted in all these matters.

The authority of the school council comprises the supervision of instruction, the appointment of the director and vice director of the school, as well as that of managing officers, etc.; the assignment of salaries, within the limits imposed by the Federal laws; the award of scholarships, reductions of fees, bestowment of prizes and diplomas.

In general, the school council attends to the current administration of the institution, aside from the weightier decisions, reserved to the Federal council, and the ordinary routine measures left to the autonomous organization of professors.

At the head of the latter organization stands the joint conference of professors of all departments. This body nominates the director of the school for approval by the school council. The director, whose office corresponds to the rectorship in the universities, is appointed for two years and may be reappointed to serve for three successive terms. His deputy (Stellvertreter) is appointed in the same manner.

The director or his deputy must attend the meetings of the school council and may take part in the deliberations.

The joint conference convenes regularly once a year, but may be invited to extra sessions at any time when emergency occurs. The conference is composed of all the teaching forces of the school, including the private docents. Its task is designated as that of "keeping always in mind the good of the institution, proposing the necessary improvements, and bringing to the attention of the authorities the existing evil conditions."

Departmental conferences, organized on similar lines and corresponding to faculty meetings at the universities, are held for the determination of matters pertaining to the proper conduct of instruction in the respective departments. Occasionally the departmental conferences are consulted by the president of the school council or the director of the school in matters of school discipline, etc.

Admission requirements.—Candidates for admission to the Polytechnic School must be 18 years of age and present the graduation certificate (certificat de maturité) of a Swiss middle school or submit to an entrance examination. Special students may be admitted for lectures in any semester on passing the required examinations. Men of mature years, who desire to attend lectures, may be exempted from strict conformity to the rules. Students of the Zurich University are admitted on presenting their card. Students who complete the course which they may have selected receive a certificate (abgangszeugnis) showing the average marks for the obligatory subjects. At the close of the courses in each division, students undergo an examination for the diploma. The fees, as expressed in United States money, are as follows:

Entrance: Registration	$2 00
Examination	4 00
Yearly school fee	30 00
Insurance against sickness and accident	1 20
Library and reading-room fee	1 00
Total	38.20

The dues for optional subjects are included in the yearly school fee of $30, but for lectures which are not obligatory and are given by the honorary professors and instructors (private docents) a special fee of $1 per weekly hour in the semester is charged. The annual term comprises two semesters, one opening April 15 and the other October 15.

The standard of admission for all regular students is high, particularly as regards mathematics, and while liberal provision is made for various classes of special students in every case proof of ability to profit by the privilege is required.

The institution is organized in the following-named divisions or departments of instruction:

	Years in course
1 School of architecture	3½
2 School of civil engineering	3½
3 School of mechanical engineering	3½
4 School of chemical technology	
In technological section	3
In pharmacy course	2
5 Agricultural and forestry division	
(*a*) Agricultural school	2
(*b*) Agricultural engineering school	3½
(*c*) Silviculture	2
6 School for special teachers in mathematical and natural science subjects:	
(*a*) Mathematical section	4
(*b*) Natural science section	3

Instruction.—The languages of instruction are French, German, and Italian, in conformity with the special conditions of the country. Instruction is given by means of lectures, repetitions, seminaries, and practical occupations. In order to be admitted to the lectures and practical occupations of the higher semesters, which presuppose acquaintance with prescribed sciences, the student must produce proof that he has (1) completed the required preliminary studies, and (2) performed the practical exercises of the respective specialty. A student who, after a specified period of time, has not passed any examinations (semester or diploma examinations) may be prohibited by the school council, upon the advice of the departmental conference, from further attendance upon the lectures.

Diplomas and degrees.—The technical departments confer diplomas of engineers, architects, chemists, etc. The departments of mathematics, physics, and science confer diplomas of "professional teachers" of these subjects (Fachlehrer).

A special examination leads to the doctor's degree.

Typical courses of instruction.—The department of civil engineering derives special importance from the difficult engineering problems that are presented by the topography of the country. The fundamental studies are the same in this department as in the department of mechanical engineering and occupy the chief place in the program for the first two years, the distribution of time between the subjects being the same for both departments and both years, as shown by the following conspectus:

SCHOOLS OF ENGINEERING.

1 year.—First and second semesters.

	Hours per week.
Differential calculus (German or French)	4
Review (in groups)	1
Exercises	2

	Hours per week.
Descriptive geometry	4
Review (in groups)	1
Exercises	4
Analytical geometry	1
Review (in groups)	4
Chemistry	2
Review	1

II year.— Third and fourth semesters.

Differential equations	4
Exercises in equations	1
Theory of differential equations	4
Review	1
Mechanics, II Part	4
Review (in groups)	1
Exercises (in groups)	2
Graphical statics, I Part	2
Exercises in statics	2
Review	1
Physics	4
Review	1

The subjects special to civil engineering occupy 7 hours a week the first year and 8 hours the second; the subjects special to mechanical engineering, 5 hours and 25 hours, respectively, of the latter 10 are given to drawing and 4 to optional exercises.

In both schools of engineering the courses of instruction for the remaining time, i. e., the third year (two semesters) and the fourth year (one semester), are fully specialized.

The school of chemical technology of the Zurich Polytechnic is noted for the breadth and completeness of its curricula, in which full recognition is given both to the scientific and practical aspects of the subject. In addition to the main section, which has a course of three and one-half years' duration, there is a pharmaceutical section with a two-years' course. The subjects and their time relations in the main section are given in the following table:

CHEMICO-TECHNICAL SCHOOL.

TECHNICAL SECTION.

I year.— First and second semesters.

	Hours per week.
Higher mathematics	5
Exercises in mathematics	2
Inorganic chemistry[1]	6
Review	1
Analytical chemistry,[1] I Part	2
"Practicum" for analytical chemistry	16
Mineralogy[1]	4
Review	1
Mechanics and engineering	4
Review	1

[1] Pertains also to the pharmaceutical section; the remaining subjects of the latter section are strictly specialized.

ZURICH POLYTECHNIC INSTITUTE.

II year.— Third and fourth semesters.

	Hours per week.
Inorganic chemical technology	4
Review	1
Heating, etc	2
Organic chemistry, Part II.[1] Benzene derivatives	2
Review	1
Practicum for technical chemistry	16
Physics	4
Review	1
Practicum for physics for beginners	4
Engineering	2
Review	1
Exercises in design	4

III year.— Fifth and sixth semesters.

Bleaching, dyeing, and dyes	4
Review	1
Metallurgy	2
Review	1
Practicum for analytical chemistry or	24
Practicum for technical chemistry	24
General botany, with reviews	4
General geology, with reviews	5
Analysis of gas, with exercises	1
Analysis of foods, with exercises	2
General electrochemistry	2
Practicum for electrochemistry for advanced students	15
Physical chemistry	2
Industrial fittings and buildings	2
Exercises in design	2
Industrial hygiene	2
Bacteriological exercises for beginners	5
Bacteriological exercises for advanced students	Daily.

IV year.—Seventh semester.

Practicum for analytical chemistry or	24
Practicum for technical chemistry	24
Practicum for electrochemistry for beginners	4
Practicum for electrochemistry for advanced students	15
Exercises in microscopic work	2
Technological botany, I. (Fibers and their strength)	2
Electrotechnics	2
Elements of national economy	3
Political economy	3

The school for special teachers of mathematical and natural science subjects has an extensive program equivalent to a four-years' course, but the branches are so arranged that students follow selected lectures in the other courses according to their needs. Participation in the seminarial exercises takes place, as a rule, in the third and fourth years.

In addition to the courses of inst[illegible]n in the specialized schools, provision is made for general scientific studies comprised in the divi-

[1] Pertains also to the pharmaceutical section.

sion of general philosophy and State economy. This is intended to prevent the narrowing effects of technical training by emphasizing the cultural bearing of the scientific elements and the importance of technics in the national economy. This section offers opportunity for the highest order of study and research in the mathematical and physical sciences, and also for the pursuit of purely cultural branches, viz, literature, modern languages, history, history of art, political economy, with which are combined subjects bearing upon the national life and history, in particular the constitution of Switzerland, and administrative and commercial law. Courses in cultural subjects are open to all students, and attendance upon at least one such course is obligatory.

The division of military science comprises a section intended for general auditors or students desiring a limited course of instruction in this specialty, and a section of a more thorough and professional character intended for military officers. By virtue of a special ordinance issued in 1911 the attendance of officers and teachers of military science upon the professional section of this division has been greatly increased.

ITALY.[1]

LOWER STAGES OF TECHNICAL EDUCATION.

The system of education in Italy provides for specialization at an early age; hence pupils looking forward to industrial and technical pursuits generally enter upon courses of instruction having that end in view as soon as they have secured the certificate of primary studies (maturità), which is generally obtained at about 11 years of age. The courses of technical instruction are provided in schools of two grades, which are, however, correlated with each other. The lowest of these is termed simply technical school (scuola tecnica), and the second, technical institute (istituto tecnico). The lower school has a three-years' course corresponding to that of the higher primary schools of France having vocational sections, or to the lower classes of modern secondary schools in Europe. The higher school (istituto tecnico), which a pupil enters at about 14 years of age, has a four years' course corresponding to that of the upper classes of the modern secondary schools of Europe. The two schools represent, therefore, two grades of technical instruction, each of which has a distinctive purpose. The courses of study, however, are so coordinated that a pupil may pass from a technical school to a technical institute and thereby complete a course of seven years having the same relation to the highest order of technical institutions that the classical secondary schools (ginnasi and licei) bear to the universities.

The courses of instruction in the preparatory schools are adapted to pupils looking forward to any one of the three great industrial pursuits, i. e., agriculture, commerce, and technical industries. For the present purpose it will suffice to consider the preparatory course having a technical orientation.

Curricula for the technical school and technical institute—Hours per week.

Subjects.	Technical school.			Technical institute (physico-mathematical section).			
	Class 1.	Class 2.	Class 3.	Class 1.	Class 2.	Class 3.	Class 4.
Italian	6	6	5	6	5	4	6
French	3	4	3	3	3	2	
English or German					3	3	5
History	2	2	2	3	3	2	
Geography	2	2	2	3	3		
Mathematics	4	4	3	6	5	5	5
Natural history		2	2	3	3		
Physics						5	3
Writing and bookkeeping			4½				
Chemistry lessons						3	
Chemistry practice							4
Drawing	4½	4½	3	6	6	4	6
Caligraphy	3	2	2				
Logic and ethics					2		
Civic instruction			1				
Total	24½	26½	27½	30	33	30	29

[1] Contributed by W. W. Shiffin, specialist in the Romance languages.

Students who complete the course of the technical school and pass the final examination which entitles one to the "licenza," may enter the technical institute. The latter course leads directly to the preparatory department of a higher technical institute.

HIGHER TECHNICAL INSTITUTIONS.

Higher technical education in Italy is the province of independent schools and technical institutes annexed to the universities. These institutions have their distinctive aims and characteristics, but are practically uniform as regards their standards of admission and graduation. The higher technical institute of Milan is here selected as representative.

R. ISTITUTO TECNICO SUPERIORE DI MILANO.

Official character and scope.—The Instituto Tecnico Superiore of Milan was established by royal decree in 1862, and in common with the royal universities and remaining special schools of the same order, pertains to the ministry of public instruction. It derives its support from the State and the Province and commune of Milan and has been the subject of special consideration on the part of the Government, as indicated by successive decrees extending or perfecting its operations. Of these the latest bears date 1897. The purpose of the institute, as officially stated, is to provide the highest order of instruction for candidates for the professions of civil engineering, industrial engineering, and civil architecture, and for teachers of the exact sciences in the technical institutes.

The institute comprises two preparatory sections, one for the course in engineering, the other for the course in architecture. The main department consists of three technical divisions (scuole di applicazione) as follows: Civil engineering, industrial engineering, and civil architecture. Each of these divisions offers a three years' course of specialized instruction. A normal section, having a four years' course, prepares teachers of physics, chemistry, and natural sciences for the technical institutes (secondary). There are also associated with the institute important auxiliary establishments which will be considered separately.

Entrance requirements.—Students who have successfully completed the course of instruction in a technical institute may be admitted to the preparatory section of the superior technical school of Milan, which completes the training in mathematics and physics required for entrance upon the specialized departments. Candidates may be admitted directly into these departments provided they have

spent at least two years in a university faculty of physical, mathematical, and natural sciences, or in the preparatory course of higher technical institutions corresponding to that of Milan. The mention in the catalogue of the institutions referred to indicates the regional influence possessed by the higher school of Milan. Among those mentioned are the school of Padua, the Polytechnic of Turin, and the higher naval school of Genoa. The attractions of the institute of Milan are increased by the associated laboratories and special institutes of private foundation. For instance, the electrochemical school not only admits students of the royal school of Milan, but offers inducements to other students, in particular to Armenians who have completed the secondary studies in the Armenian Liceo Tecnico "Moorat Raphael" of Venice, or the technical courses of the Istituto Forestale Vallombrosa.

The cases of students from foreign schools who apply for admission to the technical institute of Milan are decided by the council of professors upon consideration of the foreign diplomas which candidates must present at least a month before the opening of the school. The school year begins November 3 and ends June 30. No registrations are permitted after the beginning of lessons.

In order that diplomas and other documents issued abroad may be recognized in the Kingdom of Italy they must be visèd by the royal Italian consul in the respective foreign States. The signature of the royal consul must then be authenticated by the minister of foreign affairs in Rome.

In the scholastic year 1913–14 there were 949 students, representing nearly all the Provinces of Italy and including 52 foreign students. The faculty for the same year numbered 96, divided as follows: Ordinary professors, 13; permanent and extraordinary professors, 2; extraordinary professors, 4; instructors (incaricati), 21; free docents, 26; and assistants, 30.

Fees, examinations, etc.—The total fees for each student in the preparatory schools vary from 193.10 lire [1] to 283.10 lire; in the Scuole di Applicazione, from 213 to 473 lire, and in the normal school from 148.10 to 378 lire. These figures include small laboratory fees. As prescribed by law and approved by the royal decree of August 9, 1910, the tuition fees to be paid by each student are as follows: Matriculation fee, 75 lire; annual tuition fee—preparatory school and schools of application, 165 lire; normal school, 125 lire; diploma fee, 100 lire; Carlo Erba Electro-Technical Institute, annual tuition fee 133.10 lire; School of Electro-Chemistry, annual tuition fee, 143.10 lire.

[1] The exchange value of the lira is 19⅓ cents.

The tuition fees for foreign auditors amount to 20 lire for each course.

The annual supertax for special examinations is 20 lire; for examinations for the laurea or final diploma, 50 lire; for the repetition of a special examination, 10 lire, and for the repetition of an examination for the laurea, 50 lire.

Provision is made by which students of unusual promise but of limited resources, including foreign students under certain conditions may be relieved of a portion of the tuition fees.

Courses of instruction.—The preparatory sections have a two years' course; the subjects of instruction and the distribution of time among them are shown in the following table:

Courses of the preparatory sections.

Subject.	Hours[1] per week in—	
	Lessons.	Exercises and quizzes.
Analytical geometry	3	1
Mathematical analysis:		
First-year preparatory engineering	4	3
Second-year preparatory engineering	[2]4	2
Mathematical analysis:		
First-year preparatory architecture	3	1
Second year, preparatory architecture	[2]2	[2]1
Projective and descriptive geometry	3	6
Rational mechanics (for engineers)	4	1
Rational mechanics (for architects)	[2]3	.....
Experimental physics:		
First year	2	1
Second year	3	1
Inorganic chemistry	4½	[2]1½
Art of designing and figure:		
First-year preparatory architecture	.....	8
Second-year preparatory architecture	.....	6
First-year section of architecture	.....	8
Architecture:		
First-year preparatory architecture	.....	7
Second-year preparatory architecture	.....	[2]6
First-year section of architecture	.....	[2]9
Second-year section of architecture	.....	10
	.....	[2]9
Third-year section of architecture	.....	[2]13
	.....	[2]19
	.....	[2]21
Italian literature:		
First year	1	.....
Second year	1	.....
German language:		
First year	2	.....
Second year	2	.....
English language:		
First year	2	.....
Second year	1	.....

[1] The hours are the same for both years. [2] First semester. [3] Second semester.

The courses of instruction in the specialized departments (scuole di applicazione) of the institute cover three years, divided each into two semesters. The subjects and the number of semester hours a week given to each are shown in the following table:

Courses of the specialized departments—Hours per week.

Subjects of instruction.	Civil engineering.		Industrial engineering.		Civil architecture.	
	First semester.	Second semester.	First semester.	Second semester.	First semester.	Second semester.
FIRST YEAR.	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*
Rational mechanics	4	4	4	4	.....	3
Thermodynamics and technical physics	3	3	3	3	3	3
Science of constructions (mechanics applied to constructions)	10	9	10	9	10	9
General theory of machines (mechanics applied to machines)	6	6	6	6	.....	.....
Agricultural chemistry, I	2	6	2	6	.....	.....
Applied mineralogy and materials of construction	5	5	5	5	5	5
General and applied geology	3	3	3	3	.....	.....
Architectural design	6	6	.....	.....	.....	.....
History of architecture	2	2	.....	.....	2	2
Analytical chemistry	.....	.....	8	8	.....	.....
Mechanical technology, I	.....	.....	1	.....	.....	.....
Machine design	.....	.....	8	8	.....	.....
Ornament and figure	.....	.....	.....	.....	8	8
Perspective	.....	.....	.....	.....	7	7
Architecture	.....	.....	.....	.....	10	10
Total	41	44	50	52	45	47
SECOND YEAR.						
General electrotechnics, I	2	2	2	2	.....	.....
Hydraulics (water supply and hydraulic constructions)	7	5	7	5	.....	.....
Science of constructions (mechanics applied to constructions)	10	9	10	9	10	9
Industrial mechanics (theory of thermal and hydraulic machines)	4	3	4	3	.....	.....
Topography, I	.....	14	.....	14	.....	14
Geodesy	3	3	.....	1	.....	.....
Practical architecture	8	10	.....	.....	2	2
Agricultural chemistry	2	6	2	6	.....	.....
Agricultural science	3	3	.....	.....	.....	.....
Law and political and industrial economy	3	3	2	2	2	.....
Machine construction	.....	.....	16	15	.....	.....
Construction of thermal and hydraulic motors	.....	.....	.....	1	.....	.....
Mechanical technology, II	.....	.....	.....	3	.....	.....
Physical chemistry	.....	.....	2	2	.....	.....
Technological chemistry, I	.....	.....	[1] 11	[1] 11	.....	.....
Metallurgy	.....	.....	1	1	.....	.....
Ornament and figure	.....	.....	.....	.....	6	4
Perspective	.....	.....	.....	.....	7	7
Architecture	.....	.....	.....	.....	9	13
Hygiene applied to engineering	.....	.....	.....	.....	2	2
History of architecture	.....	.....	.....	.....	2	2
Total	42	58	58	75	40	53
THIRD YEAR.						
General electrotechnics, II	2	2	2	2	.....	.....
River hydraulics	2	2	2	2	.....	.....
Construction of bridges and maritime works	10	10	10	7	.....	.....
Road and railroad construction	3	9	2	1	.....	.....
Practical railroad engineering	3	7	2	6	.....	.....
Practical architecture	6	10	.....	.....	.....	2
Topography, II	.....	[2] 3	.....	.....	.....	.....
Rural economics and valuation	2	3	.....	.....	.....	.....
Construction of thermal and hydraulic motors, II	.....	.....	10	10	.....	.....
Mechanical technology, III	.....	.....	4	4	.....	.....
Chemical technology of paper making	.....	.....	.....	1	.....	.....
Industrial plants	.....	.....	.....	9	.....	.....
Applied mechanics	.....	.....	14	14	.....	.....
Electrochemistry	.....	.....	2	2	.....	.....
Physical chemistry	.....	.....	2	2	.....	.....
Technological chemistry, II	.....	.....	1	1	.....	.....
Technological chemistry (supplementary course)	.....	.....	4	4	.....	.....
Exercises in technological chemistry	.....	.....	11	11	.....	.....
Applications of oils, fats, and dyes	.....	.....	.....	1	.....	.....
Machinery of technological chemistry	.....	.....	1	1	.....	.....

[1] Including 8 hours of exercises obligatory only to those students who specialise in electrical engineering.
[2] Ten entire days are taken for practical work in topography. For the sake of uniformity an approximate equivalent in semester hours is given above.

Courses of the specialized departments—Hours per week—Continued.

Subjects of instruction.	Civil engineering.		Industrial engineering.		Civil architecture.	
	First semester.	Second semester.	First semester.	Second semester.	First semester.	Second semester.
THIRD YEAR—continued.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
Mining			1	2		
Aeronautics			1	1		
Decoration and figure					9	11
Perspective					9	5
Architecture					19	21
Total	28	46	78	81	37	39

Practical work.—The number of semester hours assigned for practical work is not given separately, but is included in the total time as stated in the foregoing tables. The proportion of practical exercises to the total time is expressed by the following percentages, which are averages for the three departments treated: For the first year, 60 per cent for both semesters; for the second year, 57 and 65 per cent for the first and second semesters, respectively; for the third year, 69 per cent for both semesters. The following diagram gives a graphic presentation of the same proportions.

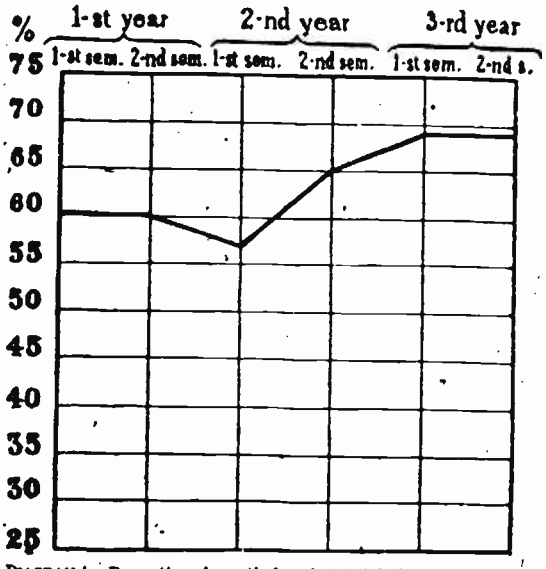


DIAGRAM 4.—Proportion of practical work to total time, Higher Technical Institute of Milan.

Optional studies.—In all departments a number of additional courses are offered as optional. These courses, while not absolutely

indispensable to the professional education of the students, are nevertheless recommended as helpful for general or special development.

The optional studies which are offered only in the second and third years, are distributed by departments and semesters as follows:

Optional studies—Hours per week.

Subjects.	Second year.		Third year.	
	First semester.	Second semester.	First semester.	Second semester.
Department of civil engineering:				
Hygiene applied to engineering	2	2		
History of architecture	2	2		
Higher analysis	2		2	
Department of industrial engineering:				
Hygiene applied to engineering	2	2		
Higher analysis	2		2	
Technology of refrigeration			1	
Electric services for mines				1
Department of civil architecture:				
Medieval archeology			1	
Institute of electrotechnics:				
Electrochemistry			2	2
Physical chemistry			2	2
Electric services for mines				1

Specialized courses for electrical engineers.—Students desiring to specialize in electrical engineering are offered a number of courses in the separate institute of electrotechnics (Istituzione elettrotecnica), but closely related with the department of industrial engineering which corresponds to that of mechanical engineering in other countries.

The electrotechnical courses cover one year and are arranged as follows:

Electrotechnical courses—Hours per week.

Subjects.	Semester hours.	
	First semester.	Second semester.
General electrotechnics	2	2
Electric plants and electric measurements	10	14
Electrical technology	3	3
Electric machines (construction and tests)	2	2
Electric plants (applications)	1	1

AUXILIARY ESTABLISHMENTS.

The auxiliary establishments, to which reference has already been made, not only afford opportunity for the students of the technical school to pursue intensively certain specialties and to extend their general researches, but they are also open to other classes of students who meet the entrance requirements, and they serve in various ways

the interests of experts and manufacturers concerned in their respective specialties. These associated institutes are as follows:

Carlo Erba Electro-Technical Institute.
School of Electro-Chemistry.
R. Stazione Sperimentale per l'Industria della Carta e lo Studio delle Fibre Tessili in Milano.
Scuola Laboratorio e Stazione Sperimentale per l'Industria degli Olî e dei Grassi.

The purpose of the first two associate institutes is sufficiently indicated by their titles.

The purpose of the R. Stazione Sperimentale per l'Industria della Carta e lo Studio delle Fibre Tessili in Milano is to promote experimental researches in respect to problems relating to the paper industry and products employed as textile fibers, and to publish the results of these researches; to publish the results of similar investigations and the application of new methods and processes which are proposed for the paper industry when they are recognized as really useful; to study the use of new materials, indicating their utilization and their value; to make chemical and microscopic analyses of the principal materials and the products of the paper industry, and the industry of textile fibers; to furnish advice and theoretical and practical instruction to manufacturers and operatives; to supply statistical reports regarding the commerce and economy of the paper industry, the use of textile fibers, etc. In furtherance of its broad purposes, manufacturers and operators are encouraged to make free use of the equipments of the station. Courses of instruction adapted to operatives are maintained, and public lectures on the progress of the paper industry and of the studies of textile fibers. The station also conducts analyses and gives valuations in reference to its specialties for the use of Government officials and private individuals.

The Scuola Laboratorio e Stazione Sperimentale per l'Industria degli Olî e dei Grassi, as its name indicates, affords special facilities for studies and practical investigations regarding the industry of oils, fats, ether oils, perfumes, colors, and varnishes. The laboratory also publishes the results of all recent discoveries and inventions relating to its specialty and makes analyses and estimates for those interested in the industries of oils and fats.

The Scuola Laboratorio e Stazione Sperimentale per l'Industria degli Olî e dei Grassi is divided into two sections: The section of operatives and the section for those seeking the position of chemical director. Each section has a two years' course—one of preparatory work and one of application. Admission to the first section is free and open to all operatives who have passed the examination of the third elementary year, who have worked at least one year in an establishment, and who have reached the age of 17. To be admitted to the second section, the applicant must be 17 years old and have the *licenza technica* or

ginnasiale, or some other equivalent title, and give proof of having worked for one year in an establishment. Those having the *laurea* in chemistry and industrial engineers may be admitted immediately in the second year.

EXAMINATIONS.

Examinations hold an important place in the general scheme of higher technical education. They comprise both oral and written exercises, and include graphic work and structural plans according to materials designated. The ability of students to continue in the course is tested by annual examinations, and students who fail to receive a mark of at least 60 per cent are obliged to repeat the course in the subjects in which they are weak, although they may be registered as regular students in the following year's course. As a rule a student can not repeat a year's course in any subject more than once and must pay the fee for special examination in every subject in which he was deficient. At the end of the third year, students who have successfully passed all the prescribed annual examinations are eligible for the examination for the laurea (doctor's diploma). Students rejected at this examination have the privilege of repeating it in the December session of the same year by paying the supertax of 50 lire. Those who fail in that session can not present themselves again until the close of the following scholastic session, when they must again pay the supertax. No one is permitted to attempt the examination for the laurea more than three times.

The laurea is conferred for the following courses: Engineering, architecture, physics, chemistry, and natural sciences.

Students of the normal section who have passed the required examinations receive the certificate of pedagogic ability, carrying mention of physical, chemical, or natural sciences, according to the course followed.

Special diplomas are also conferred by the associated institutes.

FINANCIAL SUPPORT.

During the year 1911–12 (the latest year for which figures are available) the State contributed the sum of 277,600 lire ($53,576.80) for the maintenance of the main institution and 75,000 lire ($14,475) for the purchase of materials. The Carlo Erba Electro-Technical Institute is supported by an endowment fund of 400,000 lire ($77,200), bequeathed by the famous engineer, Carlo Erba. The School of Electro-Chemistry is endowed by the Cassa di Risparmio (savings bank) delle Provincie Lombardi with a capital of 300,000 lire ($57,900) of which 50,000 lire ($9,650) was set aside to be used in establishing the plant and institute, and the remaining 250,000 lire ($48,250) was destined to support the institution.

The R. Stazione Sperimentale per l'Industria della Carta is under the control of the minister of agriculture, industry, and commerce. The following are its sources of income: The minister of agriculture, industry, and commerce, 8,000 lire ($1,544) annually; Commune of Milan, 4,000 lire ($772) annually; Societa Umanitaria di Milano, 1,000 lire ($193) annually; Chamber of Commerce of Milan, 21,000 lire ($4,053) annually; Province of Milan, 1,000 lire ($193) annually. The R. Istituto Tecnico Superiore contributes the ground on which the factory stands, and provides for the maintenance of the rooms, illumination, heating, and supply of water.

Faculty, students, and finances of the technical institutions.

Institutions.	Date of establishment.	Number of main departments	Members of faculty.	Students in 1913 13.	Financial support, 1912 13 (lire).
Istituto tecnico superiore, Milan	1863	4	[1] 86	915	[2] 332 (00)
Scuola di applicazione per gli ingegneri, Bologna	1877	2	[3] 20	198	868,051 80
Scuola superiore politecnica, Naples	1863	3	41	[4] 881	285 (00)
Scuola di applicazione per gli ingegneri, Rome [5]	1873		44	[3] 663	851,745 (0)
Politecnico, Turin	1906	4	77	1,519	758 90)
Scuola superiore postale-telegrafica-telefonica, Rome		2		42	146, 470 86

[1] Including 30 assistants.
[2] 1911–12.
[3] Including 12 assistants.
[4] 1914 15.
[5] 1913 14
[6] This institution pertains to the University of Rome

AUSTRIA.

ORGANIZATION OF HIGHER TECHNICAL EDUCATION.

Higher technical education in Austria is provided by seven higher technical schools (Technische Hochschulen), which are remarkably uniform in regard to administration, programs of instruction, and internal regulations. The main facts and figures relating to these schools are comprised in the table on page 75.

Administration.--Higher technical schools pertain to the ministry of education. The State contributes liberally to the maintenance of these institutions, but does not interfere with their administration, which is exercised by the "college of professors" under the presidency of the rector. The college consists of all the ordinary and extraordinary professors of the school and several delegates representing the private docents. The rector is elected by the college from the number of ordinary professors for one school year. The retiring rector, called "prorector," retains certain vestiges of authority; for example, he fills the office of rector in the absence of the latter.

Similar administration is provided for each department of the school; the professors of the department form a "departmental college of professors" and elect a dean as their president for one school year.

Besides the ordinary and extraordinary professors, the schools employ private and honorary docents and lectors, the latter title being usually applied to instructors of foreign languages. There are also assistants to aid the regular professors in their work and adjuncts to assist in experiments and demonstrations. The professors are appointed by the Emperor, upon the recommendation of the minister of education. The private docents and adjuncts are appointed by the minister himself.

Admission requirements.--The certificate of *maturity*, showing the completion of the course of a gymnasium, a real school, a real gymnasium, or a reformed real gymnasium, is necessary for admission to higher technical schools. Graduates of classical gymnasia are required to give proof of adequate training in drawing, both geometrical and freehand.

No matriculation examinations are held in the higher institutions, but secondary schools admit externs to the maturity examinations, and if they pass give them certificates identical with those awarded to their own pupils.

Auditors and guests may be admitted to single lectures or a course of lectures without proof of secondary education.

Foreigners are admitted as students or auditors upon the authorization of the dean of the respective department or of a special com-

mittee of admission; questions arising as to the value of foreign certificates presented by candidates are decided by the minister of education.

PROGRAMS AND METHODS OF INSTRUCTION.

Instruction.—The courses of instruction in most of the departments are of four years' duration. In architecture, however, they cover generally five years. There are also short courses for surveyors and insurance experts.

Programs and methods of instruction are very similar in all the schools here considered. All have departments of mechanical and structural engineering; with one exception all have departments of chemical engineering, and all but two are provided with departments of architectural engineering. A general department is also a common feature. Electrical engineering, agriculture, "kultur" engineering, hydraulic engineering, and geodetical engineering are each offered in one school.

The general system of instruction closely approaches the German system, as analyzed in the case of the Charlottenburg school. All the Austrian schools have ample facilities for practical work; all employ specialists teaching highly differentiated subjects; and all assign considerable time to practical instruction.

At the end of the second year the students are required to submit to the first State examination. The second State examination is held at the end of the last year. Frequent examinations in single subjects are held during the course.

Language of instruction.—The language of instruction in four out of the seven higher technical schools in Austria is German; in the Lemberg school the instruction is in Polish; Brünn and Prague have each two higher technical schools, the language of instruction being Bohemian in one of the schools and German in the other.

Degree.—The degree conferred in all the technical departments is that of doctor of technical sciences (Dr. techn.). It is awarded to those who, after the completion of the full prescribed course, in one selected department, present a thesis on a scientific subject and pass the final examination (rigorosum). Instead of a scientific thesis, a construction design may be accepted, if accompanied by technical description and a scientific motivation, showing the author's ability for independent work.

Length of the school year.—The school year begins the first of October and closes at the end of July.

The vacations amount to 99 days, or a little over 14 weeks. The school year comprises, therefore, approximately 38 weeks.[1] This time is divided into two semesters, winter and summer, the former ending and the later beginning on March 1.

[1] From this number several more days must be deducted for national and local holidays.

Higher technical schools of Austria.

Institutions.	Date of foundation.	Year of report.	Professors and students.	Number of students by departments.										Total.	Annual expenditure, in crowns.
				Structural engineering.	Architectural engineering.	Mechanical engineering.	Electrical engineering.	Chemical engineering.	Agriculture.	"Kulturingenieur-ing."	Hydraulic engineering.	Geodetical engineering.	General department.		
Vienna Higher Technical School	1815	1910–11	206	1,352	243	935	94	246	.....	.....	.....	.....	366	3,239	1,328,320
Graz Higher Technical School	1811	1910–11	66	317	41	219	.....	58	.....	.....	.....	.....	78	713	494,367
Prague German Higher Technical School	1717	1910–11	98	346	40	240	.....	124	.....	.....	.....	.....	190	940	803,669
Prague Bohemian Higher Technical School	1718	1910–11	210	901	163	648	.....	328	172	205	.....	.....	580	2,997	1,392,763
Brunn German Higher Technical School	1846	1910–11	113	278	.....	232	.....	103	.....	.....	.....	.....	126	741	.....
Brunn Bohemian Higher Technical School	1899	1910–11	79	228	.....	183	.....	.....	.....	.....	.....	.....	180	541	.....
Lemberg Higher Technical School	1817	1910–11	123	728	196	446	.....	183	.....	.....	98	99	.....	1,745	828,049

RUSSIA.

INTRODUCTION.

General features.—Higher technical education in Russia is provided in polytechnic institutes offering instruction in all recognized branches of engineering science, and special institutions devoted to the teaching of one selected branch with a view of preparing highly specialized engineers for positions in Government service or industries. There are also three schools of intermediate type, termed technological institutes, which offer two departments, mechanical and chemical, and are in their essential features but incomplete polytechnic institutes.

The organization of the Russian polytechnic institutes presents few distinctive traits, while that of special technical schools requires more particular consideration.

Technical education in Russia is under several different ministries, each having absolute control of its own province. The ministry of public instruction controls many technical schools, but those under other ministries are by no means unimportant. The department of agriculture alone disburses for its agricultural schools a larger sum than that expended by the ministry of public instruction for all technical schools under its control. The ministry of commerce and industry controls a number of polytechnic institutes and schools of commerce. The grouping of these several classes according to the respective ministries responsible for their supervision and maintenance is shown in the table appended to this section, page 91.

PREPARATORY EDUCATION.

Standard of preparation.—Notwithstanding the divergency of administrative systems and programs, all Russian technical schools of the higher order have certain common features. Among these are the admission requirements, which are essentially the same whether for polytechnic institutes or special institutions for any branch. The standard of these requirements is the full course of a gymnasium with eight classes. Diplomas of other secondary schools are honored if they represent an amount of work equal to the gymnasium course.

Gymnasiums and real schools.—The section on Germany gives a detailed account of the three representative types of secondary education in that country: The gymnasium, the realgymnasium, and the "ober" real school. The Russian secondary schools present, mutatis mutandis, a fair copy of the corresponding German institutions. All Russian real schools are "ober," since they are all equipped with the seventh class. The German realgymnasium finds a parallel in the Russian reformed gymnasium established by the decree of 1902. Intermediate between the ultraclassical and the reformed gymnasiums is the type of 1905, which limits the time given to Latin and Greek and introduces intensified modern language study and natural science.

The amount of knowledge represented by diplomas of the secondary schools enumerated is a well-known educational quantum, and Russian graduates hold their own in any test or comparison with western European graduates of similar institutions.

Gymnasiums and real schools are all controlled by the ministry of public instruction.[1] As regards the other secondary schools whose diplomas are recognized for admission to higher technical institutions, they require, owing to their multiplicity and differences of scope and organization, a more detailed presentation.

Secondary technical schools.—The secondary schools above considered pertain to general education. All other secondary schools are termed technical and fall under the control of different ministries, according to their special character. This presentation will be limited to those that serve as feeders for places of higher technical education.

The secondary technical schools of the ministry of public instruction have a four-year course which was originally designed to give a complete technical education of a lower degree than that of higher technical schools. The original regulations required for admission to secondary technical schools the completion of five classes of a real school. Since, however, very few realists took advantage of this opportunity, preferring to complete the real school course and then enter the higher technical schools, the secondary technical schools were compelled to disregard the rule and to lower their admission requirements so as to admit pupils from two-class elementary schools and even persons without any school education, but having practical experience in factory work. There are five types of secondary technical schools under the control of the ministry of public instruction, respectively: (1) Mechanico-technical, (2) chemico-technical, (3) technical school of architecture, (4) technical school of rural economy (agriculture), and (5) technical school of mines.

[1] With the exception of some gymnasia for girls controlled by the board of institutions of Empress Mary.

Curricula of the technical schools.—The following tables give the respective curricula of the five divisions. Before passing over to the tabular form of their presentation, it must be mentioned that the secondary technical schools, as here treated, are now regarded as a transient type, and a very strong movement is on foot to develop a new kind of technical school combining the features of the existing lower and secondary technical schools and equaling in scope the real or the commercial schools. This movement is an outcome of the precarious position in which the existing secondary technical schools have been placed by the want of definite admission rules already referred to.

Curriculum of the secondary technical schools—Hours per week.

Subjects of instruction.	Mechanico-technical school.					Chemico-technical school.					School of architecture.				
	Classes.					Classes.					Classes.				
	1	2	3	4	Total.	1	2	3	4	Total.	1	2	3	4	Total.
Religion	1	1	1	1	4	1	1	1	1	4	1	1	1	1	4
Mathematics	3	3			6	3				3	3	3			6
Natural history						2	2	2		6					
Physics	3	3		2	8	3	3			6	3	3			6
Chemistry	3	2			5	3	3	4		10	3	2			5
Mechanics	5	2			7	5	2			7	5	2			7
Machine construction		2	8		10		2	2		4		2	2		4
Mechanical productions		2	3	6	11				3	3					
Chemical productions				3	3			6	8	14			2		2
Architecture		3			3		3			3		4	7	6	17
Surveying and leveling	3				3						3				3
Commercial geography and political economy			2	1	3		2	1		3					
Bookkeeping and commercial correspondence			2	2	4			2	2	4			2	2	4
Law				2	2				2	2				3	3
Total	18	18	16	17	69	17	18	18	16	69	18	17	14	12	61
Drawing subjects:															
Geometrical drawing	6	6			12	4	4			8	6	4			10
Technical drawing			6	12	18			4	4	8			6		6
Architectural drawing			3		3						2	3	10	20	35
Drawing, freehand	3	3			6	4	2			6	10	8	6	4	28
Total	9	9	9	12	39	8	6	4	4	22	18	15	22	24	79
Practical work in the—															
Mechanical workshops	9	9	9	9	36	9				9	6	10	6	6	28
Chemical laboratory		2			2		18			28					
Techno-chemical workshops								8	20	28					
Total	9	11	9	9	38	9	18	18	20	65	6	10	6	6	28
Grand total of hours	36	38	34	38	146	34	42	40	40	156	42	42	42	42	168

Curriculum of the secondary technical schools—Hours per week—Continued.

Technical School of Rural Economy.						Technical School of Mining.					
Subjects of instruction.	Classes.					Subjects of instruction.	Classes.				
	1	2	3	4	Total.		1	2	3	4	Total.
Religion	1	1	1	1	4	Religion	1	1	1	1	4
Physics and meteorology	4	2	....	....	6	Mathematics	3	3	....	....	6
Natural history and entomology	6	3	2	....	11	Physics	3	3	....	....	6
General and agricultural chemistry	4	3	2	2	11	Natural history	2	3	....	....	5
Technology of agriculture	....	4	3	2	9	Chemistry	3	2	4	....	9
Architecture as applied to agriculture	....	....	2	2	4	Mechanics	5	2	....	....	7
Agriculture, general and special	3	3	3	3	12	Machine construction	....	....	2	2	4
Management of cattle	....	2	2	....	4	Mining	....	....	2	2	4
Implements and machines of husbandry	....	....	3	2	5	Metallurgy and the technology of metals	....	2	3	5	10
Agricultural economy and bookkeeping	....	....	....	2	2	Chemical production	....	....	4	4	8
Surveying and leveling	....	....	....	2	2	Mine surveying	....	2	....	....	2
Law	....	....	....	2	2	Bookkeeping and correspondence	....	....	2	2	4
						Law	....	....	....	2	2
Total	18	18	18	18	72	Total	17	18	18	18	71
Drawing subjects:						Drawing subjects:					
Instrumental drawing	....	2	4	4	10	Instrumental drawing	2	4	6	6	18
Freehand drawing	4	2	....	....	6	Freehand drawing	4	2	....	....	6
Total	4	4	4	4	16	Total	6	6	6	6	24
Practical work in the—						Practical work in the—					
Chemical laboratory	....	8	8	8	24	Chemical laboratory	....	8	8	8	24
Techno-chemical workshops or factories	20	12	12	12	56	Techno-chemical workshops or factories	18	10	10	10	48
Total	20	20	20	20	80	Total	18	18	18	18	72
Grand total of hours	42	42	42	42	168	Grand total of hours	41	42	42	42	167

Aside from the technical schools of the above type, characterized by a strongly practical bias, there are other secondary technical schools combining special education with general. Of the latter type, two schools have gained special recognition as exceptionally efficient and well organized. They are: Łódź Technical School and Komissarow Technical School at Moscow.

Commercial schools.—Admission to higher technical institutions is also open to graduates of numerous other schools of secondary order, such as agricultural schools, commercial schools, cadet corps, theological seminaries, teachers' institutes, etc. Among these of most importance are commercial schools controlled by the ministry of finance. These schools have either seven classes, giving a complete secondary education of general and commercial character, or they have only the three upper classes, with a strictly special course of instruction. While many of the graduates of the commercial schools engage directly in business, or enter higher schools of commerce, there is always a considerable percentage of those who choose the

engineering career and seek admission to technical colleges and polytechnics.

Entrance examinations.—Almost all higher technical schools in Russia require, in addition to certificates of secondary education, proof of intellectual attainment in the form of entrance examination. In some of the schools it is simply an examination in special subjects, such as physics, mathematics, and drawing. In other schools there are elaborate examinations, and admission can hardly be secured by any but the ablest and best educated young men. Recently university graduates, especially those of the physico-mathematical faculty, have been attracted in large numbers to the best technological institutes, where they are accepted without examination. The cause of this movement is seen in the prospects of important careers offered by some technological institutes, such as the Institute of Engineers of Ways of Communication, the Mining Institute, etc. The appearance of university graduates as competitors for admission to higher technical schools has further reduced the chances of graduates of secondary schools. It also tends to make the entrance examinations more difficult.

On the whole, the tendency on the part of Russian higher technical schools is rather to obstruct the entrance of young men seeking admission than to solicit for students, as is the case in countries where private institutions prevail. Two underlying facts explain this peculiar situation of Russian higher technical schools. The first is the inadequacy of the number of schools to the demand of Russian industries, with the result that more young men seek higher technical education than the schools can accommodate; taking advantage of this fact the schools accord admission to the choicest groups of students, preferably to university graduates, in this way raising the intellectual level of their student body. The other cause of rigid admission requirements lies in the specific purposes of Russian higher technical schools. A majority of these schools were established by the Government to meet suddenly created demands for engineers in this or that branch of industry, commerce, or transportation. They are all State supported or State aided, and the Government does not hesitate at heavy expenditures connected with the maintenance of old schools and establishment of new ones. But, on the other hand, it takes careful measures to obtain from the graduates a fair return to the country by work in native industries. This consideration explains the fact that many Russian higher technical schools refuse admission to foreigners; many have clauses binding the students to serve in Government positions a certain minimum period after the graduation; in all the schools academical degrees convey also high civil ranks. There is also an evident purpose to insure that the student body shall be recruited chiefly from the Russian

population. Most of the schools limit the percentage of Jewish, and one school even the percentage of Polish, students, while all require that candidates for admission shall give proof of loyalty to the Government.[1]

ORGANIZATION OF HIGHER TECHNICAL EDUCATION.

Administration.—All educational institutions in Russia are under close control of the Central Government, which dictates their statutes, curricula, rules, and regulations of discipline. This control is exercised by the Government through the channels of several ministries. As a rule, general education converges in the ministry of public instruction, while the different branches of technical education are under the control of other ministries. All higher educational institutions in Russia are State supported; in some cases, however, they are aided by local contributions.

The internal administration of higher technical schools is in the main features uniform, irrespective of ministry affiliations. It is exercised by a council of professors under the presidency of a chief officer whose official title is "rector" in some schools and "director" in others. He is elected by the faculty of professors and must be a professor himself. His election is subject to the approval of the Emperor. A vice director supervises the instruction. Business management of the institution is intrusted to a business committee presided over ex officio by the rector. The business committee is also elected. Slight deviations from this system are allowed in some of the schools, to meet certain local or special needs and conditions. For instance, in the administration of the Ekaterinoslav Higher School of Mines, local manufacturers are given voice as members of the school council; to this end, the statute of the institution provides for the participation in the council of four representatives of the Association of South Russian Mine and Smelter Industries and of the chief of mining administration for South Russia.

Instruction.—In the highest special technological institutes the course of instruction covers from five to seven years. In polytechnic institutes it is generally four years, and in one case, namely, that of the Riga Polytechnic Institute, a commercial course of three years' duration is offered. The instruction is partly theoretical, partly practical. The latter side of the training is given marked emphasis in Russia. In most of the schools regular programs include excursions to and practical work in factories, railroads, and mines, while some others are lavishly equipped with cabinets, laboratories, and experimental shops. Special interest attaches in this connection to the Imperial

[1] According to recent press advices, the revolutionary Russian Government has rescinded all limitations, pertaining to nationality, for admission to educational institutions of every class.

Technical School of Moscow, which maintains great machine shops conducted on a commercial basis, in which students receive their practical training.

The allotment of time between the theoretical and the practical instruction is not regulated by any uniform system. It seems that in Russia this question is in its experimental stage, just as it is in other countries. There are schools embodying either one or the other extreme view in the matter; in some the practical and the theoretical instructions are closely interwoven throughout the course, while in others whole semesters are given to practical work entirely. An example of the latter type is the Moscow High School of Engineering (different from the Moscow school mentioned above), in which two years are devoted to practical work exclusively.

Degrees.—By the successful passage of the leaving examination the student generally qualifies for a degree. The degrees in engineering conveyed by the Russian institutions are the following: Engineer-technologist, electrical engineer, engineer-architect, engineer of metallurgy, engineer of ways of communication, construction engineer, and agronomist. Postgraduate study and presentation of some original work lead to the degree of "learned engineer-technologist."

Number of schools.—There are now in Russia 16 higher technical schools, as follows:

Five polytechnic institutes under the ministry of public instruction, located, respectively, in Petrograd, Moscow, Kharkof, Riga, and Tomsk.

Three polytechnic institutes under the ministry of finance, in Kief, Warsaw, and Petrograd.

Two mining institutes under the ministry of finance, in Petrograd and Ekaterinoslav.

Two engineering institutes under the ministry of ways of communication, in Petrograd and Moscow.

One institute of electrical engineering pertaining to the ministry of the interior, in Petrograd.

One institute of civil engineering under the ministry of the interior, in Petrograd.

Two higher technical schools have been established recently but are not included in this presentation. They are: Polytechnic Institute of the Don, located in Novotcherkassk, established in 1907, and Polytechnic Courses for Women at Petrograd, opened in January, 1906. No official account of these two institutions is yet available.

All particulars pertaining to the 14 institutions enumerated above are presented in tabular form in the appendix to this section.

INSTITUTE OF ENGINEERS OF WAYS OF COMMUNICATION.

(Institut Inzenierov Putej Soobščenija.)

History and object of the institution.—The Institute of Engineers of Ways of Communication was established in 1809, originally as a school of military engineers, organized along the lines of the famous French institution, "École des ponts et chaussées." The first professors of the institute were French engineers, former professors or graduates of the French school; the instruction was in French, and the military organization remained in force until 1864. The original purpose of the institute was to prepare engineers for the army service, and the students were promoted during the course through successive military grades, until finally they were graduated as second lieutenants and passed from the school directly into service in the engineering branch of the army. The reform of 1864 abolished the military organization of the institute and made its distinct purpose the training of civil engineers specializing in roads and waterways. The present statute regulating the school has been in force since 1890.

Administration.—The administration of the institute is vested in the council of the institute under the presidency of the director. An inspector is charged with the enforcement of discipline. The council decides in matters of lesser importance, pertaining to temporary measures and regulations, program of studies, conduct of practical work, etc.; in questions of greater consequence the council submits its opinion to the minister of ways of communication who is ultimate authority in the administration of the institute. The financial affairs of the institute are in charge of a special committee of finance, which also consists of professors.

Sources of maintenance, and tuition.—The institute is maintained entirely by the Government, but owing to comparatively high tuition fees (50 rubles per semester) nearly one-half of the expenditure is covered from the latter source. In 1912 the State provision for the institute was 168,240 rubles; the students' fees amounted to 126,000 rubles. The number of students at that time was 1,267. There is a provision for free scholarships and board for 50 students; the funds for this purpose are furnished by railroads and private citizens. The total amount of scholarship funds is 250,000 rubles. The students who are granted free scholarships must sign a pledge to serve in Government positions one and a half years for each year of scholarship.

Degree.—The leaving examination leads to the degree of "engineer of ways of communication." By virtue of this degree the graduate acquires the civil rank of tenth or twelfth class, according to his success in the examination. The best graduates may, after two years of

practice, become attached to the institute in the capacity of aspirants for the position of instructor. As such they receive free board and means of study. In each individual case, however, the sanction of the minister of ways of communication is necessary. The examination for the position of adjunct may take place in two years after graduation, and includes a report on practical work in which the graduate has been engaged since he left the institute, an oral examination, a thesis, and two trial lessons.

Admission requirements.—The candidates for admission must present a certificate of maturity and submit to a competitive examination in algebra, arithmetic, geometry, trigonometry, physics, drawing, Russian language, and one foreign language. University graduates are accepted without examination and have precedence of all other candidates. University graduates of the physico-mathematical faculty may be admitted to the second or the third year after passing an appropriate examination. How these admission rules operate to sift the enormous numbers of candidates, with the view of selecting the most promising, may be inferred from the fact that often fully half the candidates fail to pass the tests and that only a part of the remaining half is accepted; among those refused admission often are students of great ability, as is shown by average ratings received by them in the examination, often reaching 4.5 and over, or 90 and over by the centenary system.

As a rule, foreigners are not admitted to the institute, but exceptions are made upon the recommendation of the minister of ways of communication.

Curriculum.—The program of studies covers five years and includes class study and practical work in laboratories, shops, etc. The subjects of class instruction are the following:

FIRST YEAR.

1. Religion.
2. Higher mathematics.
3. Elements of mechanics.
4. Descriptive geometry.
5. Physics.
6. Chemistry.
7. Geodesy.
8. Architecture.
9. Foreign languages: French, German, and English.

SECOND YEAR.

1. Religion.
2. Higher mathematics.
3. Theoretical mechanics.
4. Constructional mechanics.
5. Graphical statics.

SECOND YEAR—continued.

6. Architecture.
7. Construction.
8. Higher geodesy.
9. Descriptive geometry.
10. Geology and physical geography.
11. Physics.
12. Foreign languages: French, German, and English (optional).

THIRD YEAR.

1. Railroads.
2. Roads.
3. Steam engines.
4. General principles of machine construction.
5. Architecture (including heating and ventilation).

THIRD YEAR—continued.

6. Electrotechnics.
7. Hydraulics.
8. Constructional mechanics.
9. Theoretical mechanics.
10. Technology of building materials.
11. Manufacture of metals.
12. Political economy and statistics.

FOURTH YEAR.

1. Railroads.
2. Waterways.
3. Bridges.
4. Constructional mechanics.

FOURTH YEAR—continued.

5. Harbor constructions.
6. Locomotives.
7. Lifting machines.
8. Drainage and irrigation.
9. Hydraulic motors.
10. Water supply and sewerage.
11. Electrotechnics and power transmission for distance.

FIFTH YEAR.

1. Operation of railroads.
2. Geology of Russia.

Practical Work of Students.

Showing number of tasks to be performed by each student.

FIRST YEAR.	
Drawing:	
Geometrical and technical	8
Topographical	3
Plain	7
SECOND YEAR.	
Exercises relating to—	
Constructional mechanics	2
Graphical statics	1
Constructional arts	2
Projectional drawing	1
Architectural drawing	2
Plain drawing	3
THIRD YEAR.	
Exercises relating to—	
Civil architecture	2
Preparation of estimates	1
Constructional mechanics	2
FOURTH YEAR.	
Architectural projects Civil or railroad construction with complex metal coverings	1
Exercises relating to—	
Bridges	1
Waterways	1
Hydraulics	1
Locomotives	1
Water supply and sewerage, or electrotechnics	1
FIFTH YEAR.	
Preparation of projects in:	
1. Bridges	1
2. Railroads, or water supply and sewerage	1
3. Waterways and harbor constructions	1
4. Practical mechanics	1

Repetitions.

	Repetitions.
FIRST YEAR.	
Higher mathematics	6
Theoretical mechanics	4
Geodesy	3
Descriptive geometry	3
SECOND YEAR.	
Higher mathematics	4
Theoretical mechanics	3
Constructional mechanics	2
Graphical statics	2
Petrography	1
Constructional arts	1
THIRD YEAR.	
Theoretical mechanics	2
Steam engines	1
Constructional mechanics	1
Hydraulics	1
Electrotechnics	1
FOURTH YEAR.	
Bridges	1

Laboratory work.—The laboratories attached to the institute are: Mechanical, chemical, and physical.

The mechanical laboratory is used mainly for testing structural materials: Cement, iron, wood, and stone. The work done in this laboratory, besides being of educational importance to the students of the institute, serves the interests of the native industries and transportation, since tests are made here of samples of constructional materials supplied from all parts of Russia. This part of the laboratory's activity is described more fully under a separate heading.

The chemical laboratory is utilized for practical occupations in general chemistry, especially by students of the first year; it is also used for chemical tests of constructional materials. The students of the advanced classes do optional work in the laboratory in qualitative analysis and technical quantitative analysis of constructional materials.

The physical laboratory furnishes the means of practical instruction in physics to the students of the second year, in connection with their theoretical study of physics; special emphasis is placed on heat, light, and electricity.

Summer occupations of students.—All students of the fourth and the fifth years, and part of the students of the first three years, are sent after the close of the spring examinations to different constructional works for practice.

The following work is included in the program of summer occupations: (1) Railroads: Research work, construction, and operation; (2) roads; (3) waterways; (4) harbor construction; (5) machine plants and shops; (6) different kinds of governmental road-building works conducted under the ministry of ways of communication.

The students of the lower classes who do not take part in the above summer occupations are engaged during a part of the summer vacation in topographical exercises, astronomical and hydrometrical observations, and boring of artesian wells.

Tests of constructional materials.—The mechanical laboratory of the institute, established in 1856, was destined to play an important part in the development of Russian transportation and industries. For a long time it was the only place in Russia where constructional materials, both imported and produced by home industries, could be tested with any degree of reliability. Some of the finest bridges in Russia are made of materials tested in the institute laboratory. The wider activity of the laboratory in this field dates from 1877, when, owing to large importation into Russia of foreign building materials, especially of English cement, it was found necessary to enlarge the facilities of the laboratory by the purchase of modern machinery. During the following years a series of appropriations helped to bring the laboratory equipment to a highly satisfactory condition.

The laboratory has participated in several international congresses on methods of testing building materials. It arranges public tests with the view of impressing upon those interested facts bearing upon the relative value of building materials. A series of such tests conducted in 1891–1898 promoted the introduction and spread of reinforced concrete constructions in Russia.

Other laboratories and equipment.—The institute possesses a well-equipped museum, a library of 70,000 volumes, and a photographic laboratory, outside of the laboratories described above. The Imperial Duma recently voted 901,000 rubles for additional laboratories and the enlargement of the old ones. At the present time the following laboratories are either in construction or recently completed: Electrotechnical, physical, aerodynamical, mechanical, and for locomotive construction. The laboratory for the testing of building materials is to be located in a separate building.

Publication.—The institute publishes a monthly report, issued since 1884 under the name "Sbornik Instituta Inżenierow Putiej Soobśćenja."

TECHNOLOGICAL INSTITUTE OF EMPEROR NICHOLAS I. AT PETROGRAD.

Technologičeskij Institut Imperatora Nikolaja I.

The institute was established in 1828 by Count Kankrin, then minister of finance, and put into operation in 1831. It was organized originally as a "practical" technical school with two departments, mechanical and chemical, and was connected with a number of well-equipped mechanical shops and chemical laboratories. It admitted pupils at the ages of 13 to 15 years, and offered a six-year course. In 1862 it was reorganized as an institution of university grade. Another reform in 1877 gave the institute the organization which it has preserved to this date. At the same time the buildings and laboratories were greatly improved and enlarged. In 1898 the institute was again extended and reequipped.

Administration.—The Petrograd Technological Institute is controlled by the ministry of public instruction. Its statute is identical with that of the Kharkof Technological Institute (see statistical table), and is similar in its essential features to the statutes governing the operation of Russian universities. At the head of the institute stands the council of professors, consisting of 15 members, with a director, his aids and a secretary, all elected for two years. The director's election must be approved by the Emperor; the vice director and the secretary are elected subject to the approval by the minister of public instruction. Business affairs of the institute are confided to the care of the finance committee of three members, presided over by the director.

Admission requirements.—Candidates for admission must present a certificate of maturity from a Russian gymnasium or other secondary school of gymnasium grade. When the number of applicants exceeds the number of vacancies, a competitive examination is resorted to as a means of selection of the best-prepared candidates. Since, however, the number of applicants is usually very high (about 2,000) and there are only 300 vacancies provided, the competitive examination is a chronic occurrence. The examination takes place in the middle of August and consists of mathematics, physics, and the Russian language. It is very rigorous, but in spite of this the number of candidates who have passed it successfully is always greater than the number of available places.

The tuition fee is 50 rubles per annum. There is a provision for free scholarships for 100 students.

Instruction and degree.—The course of instruction covers five years. The first two years are common, and during the last three years the instruction follows two specialized courses, mechanical and chemical. Practical instruction accompanies the theoretical throughout the first four years, and the fifth year is devoted entirely to practical occupations.

After the completion of the full course of studies the final examination is taken, which leads directly to the degree of engineer-technologist, entitling to the conduct of constructional work in the Empire. According to the ratings in the leaving examination, the graduates are divided into two classes; graduates of the first class receive the civil rank of the tenth degree and those of the second class the rank of the twelfth degree.

Curriculum.—The program of studies, both theoretical and practical, is as follows:

PROGRAM OF STUDIES.

FIRST YEAR.	Hours per wk.
Religion	2
Analytic geometry, advanced algebra, differential calculus, elementary integral calculus	5
Descriptive geometry	2
Physics (apparatus, measurement, molecular physics)	3
Mineralogical chemistry	5
Theoretical mechanics	3
Geodesy	2
Total	22

SECOND YEAR.	
General mechanics	2
Physics (heat, electricity)	3
General chemistry (metals)	3
Resistance of materials, organs of machines	4
Applied mechanics	3
Architecture	2
Construction	3
Integral calculus [1]	2
Analytical mechanics [2]	2
Mineralogy and geodesy [3]	2
Total	22 or 24

The program of the first two years also includes architectural and technical drawing.

[1] For mechanicians only. [2] For mechanicians only, and during one semester only. [3] For chemists only.

PROGRAM OF STUDIES—Continued.

THIRD YEAR.

Common part:	Hours per wk.
Mechanical theory of heat	4
Boilers	2
Technology of metals and alloys	2
Electrical measurements	3
Heating and ventilation	2
Total, common studies	13

Mechanicians.

Applied thermodynamics (one semester)	4
Lifting machinery (one semester)	3
Graphical statics	2
Hydraulics and hydraulic motors	2
Construction of steam engines	2
Metallurgy or iron (one semester)	2
Theory of probability (optional)	2
Obligatory total	13
Grand total	26

Chemists.

Organic chemistry	3
Analytical chemistry	2
Technology of mineral substances	4
Anatomy and physiology of plants (one semester)	3
Total	12
Grand total	25

Besides the above studies there is architectural and mechanical drawing, practical work in the shops and exercises in microscopy and analysis.

FOURTH YEAR.

Mechanicians.

	Hours per wk.
Electrotechnical theory (optional)	2
Construction and calculations of dynamos (optional)	3
Technology of textiles	4
Hydrotechnical construction	2
Theory of elasticity of solids (optional)	2
Statics of construction	3
Technology of metals	4
Construction of metallurgical works	2
Woodwork	2
Theory of locomotive construction	3
Obligatory total	20

Chemists.

Electrotechnical theory (optional)	2
Construction and calculations of dynamos (optional)	3
Technology of textiles	4
Hydrotechnical construction	2
Theoretical chemistry	4
Technological chemistry (naphtha, fats, oils, leather, paper, gas, distillation of wood)	5
Technology of coloring matters	6
Obligatory total	21

The time given to practical occupations during the fourth year is considerably increased. The practical work consists of machine design, laboratory exercises, etc. The mechanicians must design a boiler, a steam engine, and a hydraulic motor. The chemists design a boiler, a factory of chemical products relating to mineral industry. The mechanicians may select for examinations: Electrotechnics, locomotives, or technology of textile machinery.

The fifth year is devoted to the execution of designs, work at material testing in the mechanical laboratory, etc. Students spend during this year at least one month in a factory studying the branch of industry in which they are interested.

Equipment of the institute.—The library of the institute contains 12,400 works in 35,000 volumes, among them 4,579 works in the Russian language, and 837 periodical publications, among them 396 in Russian. The value of the library is estimated at 126,060 rubles.

The museum of machines, apparatus, models, commercial and other products, and scientific collections. Total of 1,640 exhibits. Value about 78,650 rubles.

Physical laboratory.

Chemical laboratory.

Technical laboratories.—For chemistry of food products, inorganic chemistry, industries based on fermentation, tannin industries, and manufacture of dyes.

Bacteriological laboratory.

Laboratory for metallurgy.

Electrotechnical laboratory.

Mechanical laboratory, with two divisions: (1) Steam engines, and (2) internal-combustion motors.

Laboratory for testing materials.

Shops, foundries, forges, pattern-making shop, metal-working shop, etc.

Publication.—The institute publishes "Technological Institute News (Izwiestja Technologićeskago Instituta).

Institutions.	Date of foundation.	Ministerial control.	Year of report.	Length of course (years).	Professors and instructors.	Students.	Departments.													Annual expenditure in rubles.
							General.	Mechanical.	Chemical.	Structural.	Architectural.	Mining.	Commercial.	Metallurgical.	Electro-technical.	Ship building.	Economical.	Electromechanical.	Agricultural.	
Imperial Technical School of Moscow	1868	Ministry of public instruction.	1912	6	112	2,690		×	×											508,440
Petrograd Practical Technological Institute of Emperor Nicholas I.	1828	do	1912	5	99	2,130		×	×											510,526
Kharkof Practical Technological Institute of Emperor Alexander III.	1885	do	1912	5-7	70	1,055	×	×	×											382,804
Riga Polytechnic Institute	1862	do	1912	3-5	88	1,970		×	×	×	×		×						×	444,704
Tomsk Technological Institute	1900	do	1912	4-5	73	1,171		×	×		×	×								422,409
Kief Polytechnical Institute of Emperor Alexander II.	1898	do	1911	4	38	2,300		×	×		×								×	
Warsaw Polytechnical Institute of Emperor Nicholas II.	1898	Ministry of Commerce and industry.	1912	4	47	600		×	×		×	×								354,900
Mining Institute of Empress Catherine II, at Petrograd.	1773	do	1911	5	64	640					×	×		×						
Ekaterinoslav School of Mines	1899	do	1912	4	34	430														155,000
Institute of Engineers of Ways of Communication of Emperor Alexander I, at Petrograd.	1810	Ministry of ways of communication.	1911	5	114	1,267														294,240
Moscow Imperial Engineering School	1895	do	1912	5	76	560														
Institute of Civil Engineers of Emperor Nicholas I, at Petrograd.	1842	Ministry of the Interior	1911	5	83	690														181,142
Electrical Engineering Institute of Emperor Alexander III, at Petrograd.	1891	do	1911	5	45	700														216,101
Petrograd Polytechnic Institute of Emperor Peter the Great.	1902	Ministry of commerce and industry.	1911	4	219	4,668		×			×			×	×	×	×	×		611,040

JAPAN.

Technical education in Japan is of recent development. Its existence dates from 1871–1875, when three schools were established, representing the three main divisions of technical education, respectively: Engineering, agriculture, and commerce. The movement, however, did not attain real importance until 1894, following the issue of an ordinance regarding the Government subsidies to technical schools. Two epochal events of Japanese national life, the Chinese war in 1894–95 and the Russo-Japanese war in 1904–5, produced two consecutive waves of national uplift which gave rise to enthusiastic educational activities. In the measures that were carried out in this movement technical education was given special attention. In 1899 the Government issued an ordinance fixing the types and determining the standards of technical education. In 1903 another ordinance was issued, by which all technical and professional schools of higher grade were given a common organization.

PREPARATORY EDUCATION.

The education that must precede the higher technical studies may be of general or technical character. It begins with the elementary school having a six-year course that covers the period 6 to 12 years of age. The elementary school may be followed by a two-year higher-elementary school or a middle school having a course of five years' duration. The latter school is generally taken by those intending later to enter a higher institution. The completion of the first two years of a middle school, or of the full course of a higher-elementary school, admits to middle technical schools, where special courses are provided in several branches enabling the pupil to begin his specialization as early as 14 years of age, with the view of following the same branch in the higher technical school, or of obtaining the necessary skill and knowledge for a skilled worker, an artisan, a foreman, etc. There are technical schools of even lower grade than the above, to which boys are admitted after finishing the elementary school.

The completion of the ordinary middle school, or of the technical school of middle grade, closes the secondary education. The graduate may then proceed to one of the imperial universities or one of the higher technical schools.

THE TWO TYPES OF HIGHER TECHNICAL SCHOOLS.

Higher technical education in Japan is provided by engineering colleges forming departments of universities, and by special technical schools. The term "special" in this relation is officially applied to the type of school higher than the secondary and not quite up to the university grade. In view, however, of the unique position occupied by these schools in the educational classification, it is desirable, perhaps, to show their relation to both secondary and higher education by actual comparison.

In regard to admission requirements, the special technical schools stand lower than the corresponding university colleges. To be admitted to a special technical school, the secondary school certificate and a rather exacting examination are all that is required. But a student can not be admitted directly from a secondary school to a university college; he must first pass through a three-year preparatory course corresponding to the first two years of a standard university. The university course following this is of three years' duration, with the exception of the departments of medicine and law, which have a four-year course.

The university course corresponds to the last two years of the American college course, with some extensions which, however, do not raise it to the plane of American graduate courses. Special provision is made for the graduate studies in the Japanese universities by the maintenance of Daigakuin, or University Halls, equipped with all facilities for research work and postgraduate studies. These postgraduate studies often are extended over five years.

It may be observed that the whole period of primary, secondary, and higher education, of which the final sanction is a university degree, is considerably longer in the Japanese than in any other educational system. This is explained by the difficulties encountered by the Japanese students in their language study; in order to follow the higher studies they must master at least one European language, which is necessarily the medium of modern scientific instruction. It is evident that the acquisition of foreign languages is much more difficult to a Japanese boy than to an American boy, the principles of etymology and syntax of European languages being utterly strange to the Japanese mind.

In relation to the university course in engineering, the course of the special technical schools may be regarded as abbreviated. The object of the latter, as stated officially, is to "give those intending to engage in agricultural, technical, and commercial pursuits a more advanced knowledge of arts and sciences." In accordance with this purpose, the instruction has more practical character, with emphasis on manual training. The departments are numerous and corre-

spond to as many different practical careers. Aside from the agricultural and commercial schools, which do not enter into this consideration, the technical schools have the following departments: Dying, weaving, ceramics, applied chemistry, mechanics, electrical mechanics, electrical chemistry, electricity, marine engineering, naval architecture, naval engineering, architecture, civil engineering, mining, metallurgy, designing, and brewing.

There is a growing tendency to raise the level of the special technical schools to the university rank. The establishment of the Port Arthur Technical School, with four-year courses in all departments, may be regarded as a step in that direction.

ADMINISTRATION.

Both the universities and the special technical schools are under the direct control of the department of education; attached to the department is the higher educational council, in which, among other high officials, are heads of all higher educational institutions, and officers in charge of primary and secondary education. The council is an advisory body, but its opinions often have decisive importance. Locally educational matters are controlled by prefects, or governors, of 47 administrative districts called prefectures.

Universities.—The internal administration of the imperial universities is based on the imperial ordinance of 1886. At the head of the university stands the director, who controls all affairs of his university and is responsible for the enforcement of discipline. He presides over the university council, composed of directors of all the colleges and one professor from each college. The council's jurisdiction affects the following matters: Courses of study, questions concerning the chairs in the university, granting of degrees, giving opinion on questions submitted by the minister of education or by the president of the university.

Directors of the individual colleges exercise general supervision over everything connected with the instruction in their respective colleges. Each college holds faculty meetings attended by all the professors of the college. The faculty meetings deliberate upon curricula of studies, examinations of students, qualifications of candidates for degrees, and questions presented by the minister of education or by the president of the university.

Special technical schools.—The organization of the special, or higher technical schools, resembles that of secondary schools. The professors take no part in the administration of the school. The director, who is the head of the school, is appointed by the Emperor and is intrusted with the entire internal administration, including supervision of the work of professors and instructors. He is responsible directly to the minister of education.

There is also an advisory body at the head of each higher technical school, called board of councilors. The board of councilors consists of the following members:

Higher officials of the department of education	2
Higher officials of the department of agriculture and commerce	2
Persons of wide experience in commercial and industrial pursuits	3 to 7

The board of councilors discusses the questions connected with subjects of study, the courses of instruction, the regulations, and such other important matters as the director may deem it necessary to submit to its consideration. The decisions of the board on special questions submitted to it are reported by the director to the minister of education.

PECULIAR FEATURES OF UNIVERSITY DEPARTMENTS OF ENGINEERING.

Preparatory courses.—Admission to university colleges is conditioned by the completion of a preparatory course of three years. These courses are provided by the higher schools (Kotō Gakko), usually connected with universities. They are divided into three sections, corresponding to the rough division of higher university courses, and the students on entering the preparatory school must at once decide about their future college studies. There is a course provided for those intending later to enter the college of law or the college of literature; another course is offered for those who intend to study engineering, science, agriculture, or pharmacy in the university course; and the third division is provided for aspirants to the medical college.

The division preparatory to the college of engineering has the following courses of instruction:

Courses preparatory to the college of engineering.

Subjects of instruction.	Hours per week.		
	First year.	Second year.	Third year.
Morals	1	1	1
Japanese language	3		
English language	8	7	4
German or French	8	7	4
Mathematics	5	4	6
Physics		3	3
Chemistry		3	5
Geology and mineralogy			2
Drawing	4	4	2
Gymnastics	3	3	3
Total	32	32	30

Theoretically, the completion of the preparatory course admits to the university course, but owing to great numbers of candidates, there has been established a rather complex system of selection based on competitive examination and numerous other considerations.

For admission to special technical schools the following conditions are required (besides the usual proof of secondary education):

1. The candidate must possess good character and sound constitution.

2. He must have a firm resolve to pursue in future an industrial career.

3. He must pass the prescribed entrance examination or fulfill the conditions upon which admission is granted without examination.

The examination is based on the last year's work of the middle school and includes English, mathematics, physics and chemistry, and drawing, both free-hand and instrumental.

Graduates of middle schools who have achieved eminent success in studies are admitted without examination.

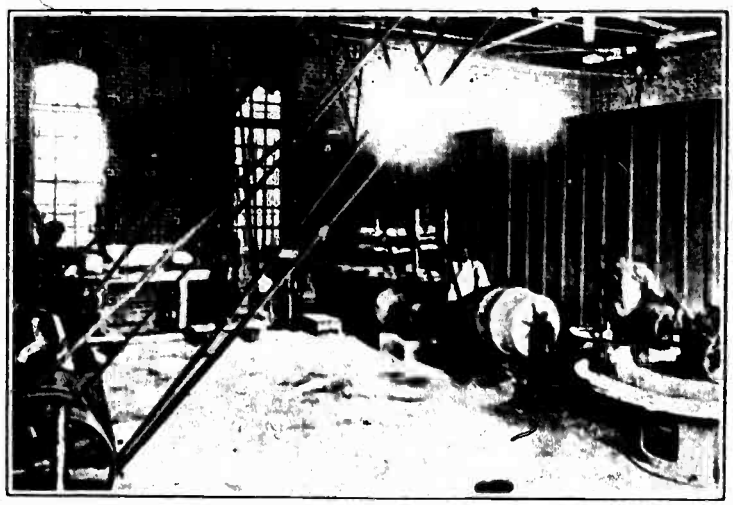
Postgraduate study and degrees.—University graduates who wish to obtain a degree must pass through a course of postgraduate studies in the university hall. Graduation itself conveys the right to the name *gakushi* and carries with it certain privileges relating to civil service, but does not impart a real academic degree. The degree equivalent to doctor or master is called *hakushi* and is used with different prefixes, according to the branch of science to which it refers. Thus, *igaku hakushi* means doctor of medicine; *hōgaku hakushi*, doctor of laws; *kōgaku hakushi*, doctor of engineering, etc.

Postgraduate studies are open not only to university graduates, but also to graduates of other higher institutions, who pass special examinations arranged separately for each individual case. Postgraduate work consists of scientific research whose subject is selected by the student and approved by the faculty of the respective department. A graduate student may also follow a series of lectures in one or several of the university colleges, according to the requirements of his special aim. If his research involves travel with scientific purposes, the administration of the university may supply him with necessary funds. At the end of each year the students must report on the progress of their work. After two years a thesis must be submitted. In addition to this the faculty may find it desirable to examine the student in certain subjects before he is granted a degree.

The period of postgraduate study may be prolonged to five years. A number of research scholarships are provided for graduates recognized as deserving by the university council.

FINANCES.

All the imperial universities, as well as all the special technical schools, are State-maintained. The Government appropriations for universities are regulated by the law of 1907. This law fixes the annual appropriation for the University of Tokyo at yen 1,380,000, for the University of Kyoto at yen 840,000; the other two universities receive varied annual grants, according to their budgets. No figures



A. TOKYO HIGHER TECHNICAL SCHOOL. PRACTICAL WORK IN CERAMICS.

B. TOKYO HIGHER TECHNICAL SCHOOL. WEAVING.

are available to show the share of the engineering colleges in the budgets of the universities of which they are parts.

As to the special technical schools, they draw their support partly from a fund called "Encouragement Fund for Technical Education," which amounted, in 1912–13, to yen 390,173.

The figures relating to income and expenditure of all the institutions that are the subject of this presentation are included in the statistical table for Japan (see p. 101).

TOKYO IMPERIAL UNIVERSITY, COLLEGE OF ENGINEERING.

The college of engineering attached to the University of Tokyo may be regarded as typical of engineering departments of Japanese universities. It offers 10 divisions as follows: 1. Civil engineering. 2. Mechanical engineering. 3. Naval architecture. 4. Technology of ordnance. 5. Electrical engineering. 6. Architecture. 7. Applied chemistry. 8. Technology of explosives. 9. Mining. 10. Metallurgy.

In view of the thorough training in elements of technical science that the students have received in the preparatory higher school, there are no common programs in the university course. Each division follows from the beginning of the first year its own course of specialized studies. It is deemed unnecessary to present here programs of all the above-enumerated divisions; the two inclosed typical programs, of the divisions of mechanical engineering and architecture, give a fair example of the arrangement of studies in all other divisions. The same two divisions in the Special Technical School of Tokyo are presented immediately following these, so that the two systems may be readily compared.

In reference to the division of the academic year into three terms, appearing in the following tables, it must be explained that the academic year at the University of Tokyo begins on the 11th of September and ends on the 10th of July. The first term, comprising 105 days, extends from September 11 to December 24; the second term of 86 days covers the period from January 8 to March 31; and the third term of 94 days extends from April 8 to July 10.

Tokyo Imperial University, College of Engineering.

A. PROGRAM OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

Subjects.	Hours per week.		
	First term.	Second term.	Third term.
FIRST YEAR.			
Mathematics	3	3	
Dynamics	1	1	1
Applied mechanics	3	2	1
Heat engines	2	2	3
Mechanism	1		1
Hydraulics		2	2
Workshop appliances	1	2	2
Building construction	2	2	
Drawing and exercises in applied mechanics	2	2	3
Design, drawing, and practice	21	19	23

Tokyo Imperial University, College of Engineering—Continued.

A. PROGRAM OF THE DEPARTMENT OF MECHANICAL ENGINEERING—Continued.

Subjects.	Hours per week.		
	First term.	Second term.	Third term.
SECOND YEAR.			
Heat engines and thermodynamics	3	3	3
Kinematics and dynamics of machinery	1	1	1
Marine engines	2	2	2
Spinning and weaving		1	1
Locomotives		1	1
Hydraulic machinery	1½	1	2
Outlines of electrical engineering	2	2	
Mechanical and metallurgical technology	2	3	3
Industrial economy		1½	1½
Experimental engineering	1	1	
Engineering laboratory	[1]3	[1]3	[1]3
Design, drawing, and practice	22	18	17
Electrical engineering laboratory			3
Practical exercises[2]			
THIRD YEAR.			
Special extra lectures		2	
Mechanical engineering laboratory[1]			
Practical exercises[2]			
Graduation design and essay[2]			

B. PROGRAM OF THE DEPARTMENT OF ARCHITECTURE.

FIRST YEAR.			
Mathematics	3	3	
Outlines of heat engine	1	1	1
Applied mechanics	3	2	1
Perspective	1		
Stereotomy		1½	
Calculation		2	2
Building materials	3		
Building construction	2	2	4
Architectural designing		2	3
History of architecture	6	6	6
Drawing and exercises in applied mechanics	2	2	2
Freehand drawing	3	3	3
Design and drawing	14	12	16
SECOND YEAR.			
Sanitary engineering		2	3
Æsthetics	1½	1½	1½
Seismology	9	3	
Building construction	3½	3½	3
Execution of works		1	3
Decoration	1	1	1
Architectural designing	3		
History of architecture	2	1	
Freehand drawing	3	3	3
Decorative drawing	3	3	3
Design and drawing	18	17	20
Practical exercises[2]			
THIRD YEAR.			
Mechanical and metallurgical technology	2	3	
Outlines of electrical engineering	2	2	
Building laws	1	1	
Freehand drawing	3	3	
Decorative drawing	3	3	
Design and drawing	25	24	
Practical exercises[2]			
Graduation design[2]			

[1] Every other week. [2] No definite time assigned.

The Higher Technological School of Tokyo.

A. PROGRAM OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

Subjects.	Hours per week.		
	First term.	Second term.	Third term.
FIRST YEAR.			
Ethics	[1]1	[1]1	[1]1
Mathematics	5	5	5
Physics	4	4	4
Shop appliances	2	2	2
Applied mechanics			4
Geometrical and machine drawing	6	6	6
Workshop practice	15	15	11
English	4	4	4
Military drill	2	2	2
SECOND YEAR.			
Ethics	[1]1	[1]1	[1]1
Differential and integral calculus	4		
Shop appliances	1	1	1
Applied mechanics	3	2	3
Hydraulics	2	2	
Steam and steam engines	2	2	2
Water wheels, etc			3
Electrical engineering	2	2	2
Machine drawing	5	5	5
Workshop practice	11	16	14
Physical experiments	3	3	3
English	3	3	3
Military drill	2	2	2
THIRD YEAR.			
Ethics	[1]1	[1]1	[1]1
Design of prime movers	4	4	3
Pumps and hydraulic motors	2		
Spinning	1	1	1
Iron and steel	1	1	
Paper machinery		1	
Oil and flour machinery			2
Locomotives		1	1
Shop practice and laboratory work	23	22	23
Industrial economics	1	1	1
Factory hygiene	[1]1	[1]1	[1]1
Industrial bookkeeping	1	1	1
Factory construction	1	1	1
English	2	2	2
Military drill	2	2	2

B. PROGRAM OF THE DEPARTMENT OF ARCHITECTURE.

FIRST YEAR.			
Ethics	[1]1	[1]1	[1]1
Mathematics	5	5	5
Physics	4	4	4
Building materials	2	1	1
History of architecture	2	3	3
Building construction	3	3	3
Designing and drawing	8	8	11
Free-hand and geometrical drawing	8	8	5
English	4	4	4
Military drill	2	2	2
SECOND YEAR.			
Ethics	[1]1	[1]1	[1]1
Differential and integral calculus	4		
Strength of materials and structure	2	2	
Graphic statics			1
Special designing	1	1	1
Building construction	2	2	2
Designing and drawing	21	25	26
Physical experiments	3	3	3
English	3	3	3
Military drill	2	2	2
THIRD YEAR.			
Ethics	[1]1	[1]1	[1]1
Building construction	1	1	1
Designing and drawing	14	15	15
Building practice	14	11	14
Surveying	1	3	
Factory economics	1	1	1
Industrial hygiene	[1]1	[1]1	[1]1
Bookkeeping	1	1	1
English	2	2	2
Military drill	2	2	2

[1] Every other week.

Professors and students in the higher technical schools.

Institutions.	Professors.	Students.	Distribution of students by departments.																			
			Civil engineering.	Mechanical engineering.	Naval architecture.	Technology of arms.	Electrical engineering.	Architecture.	Applied chemistry.	Technology of explosives.	Mining.	Metallurgy.	Mathematics.	Physics.	Pure chemistry.	Dyeing.	Spinning and weaving.	Ceramics.	Electrochemistry.	Industrial design.	Brewing.	Marine engineering.
Imperial University of Tokyo, College of Engineering	75	649	123	143	45	16	108	51	64	3	61	37										
Imperial University of Kyoto, College of Science and Engineering	57	321	41	61			98		39		27		4	8	21							
Tōhoku Imperial University, Special Department of Engineering	36	432	109	103			119				94											
Kyushu Imperial University, College of Engineering	39	152	27	25			35		30		20	13										
Tokyo Higher Technical School	88	931		192			166	79	86							32	56	30	20	37		
Osaka Higher Technical School	59	603		142	51		69		69		70							26			116	51
Kyoto Higher Technical School	26	253														88	82	83				
Nagoya Higher Technical School	34	301	84	75				64								28	45					
Kumamoto Higher Technical School	26	280	94	89							90											
Yonezawa Higher Technical School	23	114							57							17	40					
Akita Special School of Mining	22	92									59	33										

Expenditure for universities and higher technical schools.

(According to the report of the minister of education for 1912-13.)

UNIVERSITIES.	Yen.	HIGHER TECHNICAL SCHOOLS.	Yen.
Imperial University of Tokyo	1,945,226	Tokyo Higher Technical School	196,994
Imperial University of Kyoto	1,067,423	Osaka Higher Technical School	123,338
Tohoku Imperial University	723,702	Kyoto Higher Technical School	67,331
Kyushu Imperial University	810,425	Nagoya Higher Technical School	88,696
		Kumamoto Higher Technical School	70,089
		Yonezawa Higher Technical School	76,489
		Akita Special School of Mining	63,907

CANADA.

REPORT OF THE ROYAL COMMISSION ON TECHNICAL EDUCATION.

The appointment of a royal commission to inquire into the needs and present equipment of the Dominion of Canada in regard to industrial training and technical education, and to report as to systems and methods of technical instruction in other countries, indicates the awakened sense of the importance of this subject in respect to which Canada is much less advanced than in other departments of education. In the introduction to their report the commissioners presented the following summary of the present status of technical education in the Dominion:

There is handwork of some sort—hand-and-eye training—in the elementary grades of many schools from the kindergarten up. In a number of towns there are courses in manual training and household science; and other places are planning to introduce them. That is part of general education for development, for culture, and for citizenship; and it is also preparatory education to which industrial training and technical education will piece on without waste.

A beginning has been made in technical education in secondary schools in Montreal, Toronto, Hamilton, Sault Ste. Marie, and Halifax. Technical and commercial high schools in Montreal and Toronto are carrying on day and evening classes. The evening classes are attended almost wholly by young men and women who are working in some factory or shop or office during the day or are engaged in the building trades. New technical schools have been established at Montreal and Quebec, but classes in them have not yet begun. Winnipeg is erecting two new technical high schools, at cost of $700,000. There are good night schools for the workers in places like Montreal, Quebec, Toronto, and Vancouver, but not much opportunity in the way of classes in the smaller cities and towns, where the man who earns his living by craftsmanship or in industrial work can get a further training.

Several colleges and universities provide courses of a partially technical character for what may be called the technical professions. Principal Falconer, of Toronto University, was disposed to call the education provided formerly by the School of Practical Science and now by the faculty of applied science of the university, "professional and not technical." The institutions where the most advanced courses are provided are the University of Toronto, McGill University, the Polytechnic School of Laval University, the School of Mining of Queen's University, the Nova Scotia Technical College, and the University of New Brunswick.[1]

The report of the commission includes also a survey of the provision for agricultural education or the technical education of farmers, and the preparation of students for entering upon professional work directly related to rural occupations. In respect to this divi-

[1] Royal Commission on Industrial Training and Technical Education. Rept., Part I, p. 62.

sion of special education, Canada has made very marked progress and offers models for other countries.

With a single exception the institutions in Canada recognized by the commissioners as giving advanced technical education are universities. This relation, which follows English precedents, assures from the first the highest standards and sanctions for the technical professions. At the same time it promotes the helpful interchange of theoretic and practical instruction. The university excites an enthusiasm for pure science, and thus arouses latent powers which lead to original discoveries and new combinations of principles. These intellectual processes find their objective in the technical arts which react as stimuli to research.

Canada, however, as indicated by the report already cited, is fully alive to the need of provision for technical education of the secondary order. This appeals to the practical worker and is sufficient to acquaint him with the rationale of the technical arts. Every important city in the Dominion has recently made provision for this secondary order of technical education. The latest example is the central technical school building opened at Toronto with imposing ceremonies in August, 1915. The city has invested in the site, building, and equipments of the institution above two million dollars. The courses of study are intended to provide scientific, artistic, and practical training for those engaged in industrial and commercial pursuits during the day, and also to equip students for work in no less than 32 technical arts, including 10 essentially feminine industries.

At this initial stage of the movement, therefore, technical education in Canada is dealt with from the standpoint both of industrial needs and professional requirements. The former must of necessity be met by local agencies; on the contrary, young men aspiring to the higher technical careers have many inducements to complete their education in foreign countries. The desire to retain such students at home has furnished the strongest motive for the expansion of the Canadian universities in the technical direction. Representatives from the principal universities in Canada met at Toronto in the summer of 1915 to confer on this subject. At the conference it was declared—

> that at present the facilities for pursuing postgraduate courses, especially those dealing with technical matters, are extremely limited in Canada, and that large numbers of Canadian graduates go abroad and spend their time and money in foreign universities.

The opinion was expressed that—

> if postgraduate facilities were provided, this annual emigration would be gradually lessened and many students who remain abroad permanently after completing their courses would be encouraged to take up their residence in Canada.

This result would meet "the long-standing demands of Canadian manufacturers for the encouragement of research work in the higher branches of technical knowledge."

ADMISSION REQUIREMENTS FOR UNIVERSITY DEPARTMENTS.

In the several universities of Canada that have made provision for advanced technical education the admission standards are the same as those which lead to the liberal professions, the qualification of applicants being tested by an entrance examination covering the subjects of secondary education. The duration of the technical courses is the same in all cases, i. e., four years, and in general the courses are organized as a section of the faculty of applied science. Exception should be noted in the case of Laval University, Quebec, which provides for the technical studies in the affiliated polytechnic school at Montreal.

The following statement pertaining to the University of Toronto not only shows the scope of the technical education provided in that institution, but is fairly representative of the corresponding work in the other universities.

UNIVERSITY OF TORONTO—FACULTY OF APPLIED SCIENCE AND ENGINEERING.

In 1877 the Provincial Government established what was known as the Ontario School of Practical Science, which in 1900, under enactment of University Senate, became the faculty of applied science and engineering of the University of Toronto. At present the faculty has at its disposal four buildings well equipped with the apparatus requisite for thorough training in the engineering professions.

Candidates for admission to this faculty must be 17 years of age and must have completed at least four, usually five, years' preparation in a high school of the Province of Ontario, the last year being devoted especially to higher mathematics. The subjects covered by the high-school course are:

(1) Compulsory: English, history, mathematics, grammar.

(2) Optional: Three chosen from Latin, Greek, German, French, science (modern and science preferred).

The faculty of applied science and engineering comprises the following courses: Civil, mining, mechanical, electrical, chemical, and metallurgical engineering, architecture and applied chemistry.

The course in each is of four years' duration and leads to the degree of bachelor of applied science.

The average time given to instruction includes lectures 14 hours per week, laboratory 22 hours per week.

In order to secure the bachelor's degree the student must successfully pass the examination in the work of each of the four years of the course, including both theoretic instruction and practical exercises.

The elaboration of the technical courses is illustrated by the following particulars relating to civil engineering, which is selected as typical:

First Year Subjects: Mathematics; surveying, including fieldwork; physics (statics and dynamics); chemistry; commercial accounting; a modern language and drawing.

Second Year Subjects: Mathematics; astronomy; surveying, including fieldwork; mechanics; physics and chemistry, including laboratory work; mineralogy; banking; a modern language; drawing.

Third Year Subjects: Mathematics; astronomy and geodesy; surveying, with fieldwork; hydraulics; theory of structures; materials of construction, with laboratory work; engineering chemistry; geodesy; photography; physics; drawing.

Fourth Year Subjects: Theory of structures and materials of construction, with laboratory work; electricity; thermodynamics; geology, contracts and specifications; thesis on an approved technical subject, and one of (*a*) astronomy and geodesy, (*b*) sanitary and highway engineering, (*c*) structural engineering, (*d*) strength of materials and railway engineering. The student may specialize on one of the options. Particularly in the final year the practical side of the subjects treated is emphasized.[1]

M'GILL UNIVERSITY—FACULTY OF APPLIED SCIENCE.

A school of civil engineering was established at McGill University in 1858, but after five years' struggle it ceased operations. In 1871 the teaching of engineering and practical chemistry was revived and a department of practical and applied science created in the faculty of arts; in 1878 this department was organized as a faculty of applied science with a staff and teachers of its own. A few years later, through Sir William Macdonald's liberality, the Macdonald engineering building was erected, followed soon after by two additional buildings, one for physics and the other for chemistry and mining. Thus equipped and endowed, the faculty of applied science became a noted center of technical education.

The courses of instruction include the various branches of engineering, architecture, chemistry, and transportation. The department of transportation, which forms a unique feature of the institution, was established in advice with representatives of the leading railway systems of the Dominion and under the supervision of a transportation committee upon which both the railways and the university were represented. The department prepares men for the following branches of railway work: Construction and maintenance of way; motive power of department; operating department.

These courses are combined, so far as possible, with those of allied branches of engineering.

[1] For particulars respecting the organization and curriculum of the faculty of applied science, the office is indebted to Dr. Robert A. Falconer, president of the university.

With regard to the relations between the railways and the universities, the report of the royal commission already cited states that:

> The university receives from the railways the sum of $12,500 annually, of which $10,000 is employed in the payment of the salaries of the staff giving instruction in those subjects (railway engineering, railway economics, railway operation, freight service, passenger service, signals, etc.), which would not otherwise form part of the curriculum of the university, while the balance of the sum is used to strengthen that portion of the regular work of the faculty which contributes directly to the training of railway engineers.
>
> The cost to the university of training students who subsequently enter the various branches of railway service is probably about $20,000 a year. The difference between this sum and that supplied by the railways is drawn from the general university funds.
>
> Certain officers of the Canadian Pacific Railway and Grand Trunk Railway are engaged to lecture on passenger service, railway auditing, etc.
>
> Both the Canadian Pacific Railway and Grand Trunk Railway have scholarships here for some of their own men—$200 a year; failure in examination loses it. The university has arrangements with the railways for taking men who have been trained.

The degree of bachelor of science or bachelor of architecture is conferred upon students according to the course which they complete. Special students taking a shorter course and not proceeding to a degree are admitted under strict regulations. The sessional fee for the undergraduate course in architecture is $147, for all other undergraduate courses $197. The fee for matriculation examination is $5, and for examination of certificates which exempt from the matriculation test, $1. At the request of the students themselves, and by authority of corporation, an additional fee of $10 is exacted from all undergraduates and conditioned undergraduates for the support of the Literary Society, the Undergraduates' Society, the Canadian Club, the Union, the McGill Daily, and athletics.

Arrangements are made by which students may complete in six years a double course in arts and applied science. Such students pay full fees in arts for the first three years of their course, amounting to $58 annually, and the full fee for applied science for the fourth, fifth, and sixth years of the double course.

LAVAL UNIVERSITY—POLYTECHNIC SCHOOL.

Laval University, Quebec, one of the oldest institutions in Canada, makes provision for the higher technical education through the polytechnic school which is situated at Montreal and affiliated to the faculty of arts of the Montreal branch of Laval University. The polytechnic school comprises two principal divisions: The school of engineering and the school of architecture. A preparatory school included in the organization offers a course of instruction covering two years and leading to the examination for admission to the technical

divisions. The subjects of this examination and the marks allowed for each are as follows:

French..... 4	Arithmetic..... 2	Trigonometry..... 4
English..... 3	Geometry..... 5	Physics..... 3
History..... 1	Algebra..... 6	Chemistry..... 2
Geography..... 1		

Three-fifths of the total marks possible are required for passing.

A school of surveying, annexed to the faculty of arts of the university at Quebec, prepares students for positions in the provincial and Federal surveys, and also for the higher course in civil engineering at the polytechnic school. The course of instruction in surveying covers three years and is limited to mathematics and the sciences. For admission to this school the student must be at least 17 years of age and must have completed a secondary course of study, either classical or modern in character.

Engineering division of the polytechnic school.—The engineering division of the polytechnic school comprises five departments: Civil engineering, chemistry, railroads, electricity, and mines. The courses of instruction are organized in two sections: The section of sciences, covering two years, which is common to all the divisions; the technical section, providing for specialization for the two remaining years of the complete course. An examination at the end of the entire period is required, and students who pass the same successfully receive the diploma corresponding to their respective specialties, viz, civil engineering, chemical engineering, electrical engineering, etc.

Division of architecture.—The program of the division of architecture, which is very elaborate, is organized in two sections, the first covering two years, at the end of which an examination must be passed to determine the ability of the students for continuing through the third and fourth years.

In addition to the class work, students are obliged to occupy their vacations in the practice of architecture with an approved architect of the Province. Eight months of this work must be passed during the first two years of the course, and the remaining four months in the third year. Therefore the diploma of architect conferred by this section is not only proof of the completion of a thorough course of study, but of successful practice in the art under responsible direction.

An interesting adjunct of the polytechnic school is the school of decorative and industrial arts, which offers a complete course of three years, leading to a certificate which admits the recipient to the studio of decorative and industrial arts (Atelier des Arts Decoratifs et Industriels), where they may remain as long as they desire, working under the control of the polytechnic school and the immediate direction of the professors of the school of decorative and industrial arts.

NOVA SCOTIA TECHNICAL COLLEGE.

The Nova Scotia Technical College was created by legislative act of 1906, which provided for affiliating the new institution with the four existing university colleges in the Province. Of these colleges one had established four-year courses in civil and mining engineering, and the others provided for the first two years' work in engineering and were affiliated with McGill University, Montreal. In accordance with the provisions of the act of 1906 the four older colleges agreed to offer a uniform course in engineering, covering the first two years of a four-year complete course; the remaining two years in each of the four branches of engineering were given over to the technical college. By this means the opportunities for technical education were maintained in different parts of the Province, thus promoting their adaptation to local conditions; at the same time since the full program was completed in every case at the technical college, the courses were all maintained at uniform standards.

The terms of the agreement are specific in respect to admission requirements both to the university course and to the technical college. The universities require that the candidate for admission shall pass a matriculation examination in standard secondary subjects with advanced knowledge of mathematics. The technical college, while recognizing in principle the completion of the preparatory university course as valid for admission to all its specialized courses, does not, as a rule, admit candidates who have been conditioned in either physico-mathematics or drawing.

The two years' course at the technical college is organized in three sections: Civil engineering, mining engineering, and mechanical and electrical engineering. The degree of bachelor of science is conferred upon students who satisfactorily complete the work of either one of the sections.

In addition to the full technical courses, the Nova Scotia college provides for short courses in special subjects which are intended to meet the needs of men already engaged in technical pursuits desirous of increasing their attainments.

An interesting adjunct of the institution is the Halifax School of Navigation, which provides instruction in seamanship for men who wish to get a master's certificate, and similar opportunities for those who are preparing for the examination for mates and masters in inland waters on tugboats, etc. All instruction in this branch of the work is free and individual, and each person is, therefore, able to progress as fast as possible.

The provincial legislature has been very liberal in its appropriations for the buildings and equipments of the technical college. The tuition for any regular department amounts to $75 per annum. The charges for special students depend upon circumstances.

SOUTH AMERICA.

INTRODUCTION.

The States of South America have had two periods of activity in respect to technical education. The first occurred in the early days of their independent existence, when French influences determined the direction of their efforts. The second period belongs to the current history and is an outcome of the modern industrial movement which has affected in some measure every one of the Latin-American States. During the earlier period several technical schools were proposed. Most noted of these was the polytechnic school of Rio de Janeiro, Brazil, which was founded in 1810, and for several years was limited to military engineering. Its more comprehensive character dates from 1868. This institution has served as the model for other similar schools in the State, the institution at Sao Paulo being a near rival of the parent school.

The later period is particularly marked by the organization of technical departments in the universities, which, as a rule, are included within the faculty of exact sciences or that of mathematics and sciences. Notwithstanding this relation the administration and scholastic programs of the technical faculties are under their own control. The usual technical sections are engineering and architecture. The engineering section consists generally of two divisions, one limited to surveying and the other offering courses of instruction in all the recognized divisions of engineering.

The complaint is made, both by scientific men and engineers in the South American States, that the technical instruction in the universities is too exclusively theoretic. The University of La Plata has endeavored to correct this tendency, and hence, as appears from the following conspectus of the courses of instruction in that institution, a fair proportion of the time is given to practical work. In other respects the program illustrates the corresponding courses of instruction in other universities of South America.

UNIVERSITY OF LA PLATA.

Engineering education in the National University of La Plata, Argentina, is organized in the faculty of physical, mathematical, and astronomical sciences. The first year of the course of studies in this faculty is common to both the scientific and the professional sections, and comprises the higher preparatory studies in mathematics and science, corresponding to the "classe de mathematiques" of the French lycée, discussed under that country, or to a college course in the United States having mathematical bias.

The subjects and the time given to each subject in this common course are as follows:

First-year engineering course in the National University of La Plata.

Subjects.	Hours a week.		
	Theoretical.	Practical.	Total.
General physics	3		3
Geometry	2	4	6
Applications of trigonometry and algebra	2	4	6
Mathematical analysis, I	2	4	6
Drawing, I	1	5	6
Special chemistry	3		3
Total	13	17	30

The studies of the second year are different for the scientific and the professional divisions. The students of the latter follow a course more in the nature of preparation for specialized engineering studies, while those of the scientific branch continue the purely theoretical study of mathematics and science. The program of the professional division comprises in the second year the following subjects:

Second-year engineering course.

Subjects.	Hours a week.		
	Theoretical.	Practical.	Total.
General physics	3		3
Descriptive geometry	2	4	6
Mathematical analysis	2	4	6
Topography, I	2	4	6
Graphical statics	2	4	6
Drawing, II	1	5	6
Total	12	21	33

In the third year specialization takes place in the professional branch; three courses are offered, surveying, electrical engineering, and hydraulic engineering. The course for surveyors ends with the third year, while the two other courses continue for two or three years longer. The following are the subjects studied in the special course for surveyors:

Third-year course for surveyors.

Subjects.	Hours a week.		
	Theoretical.	Practical.	Total.
Law	2	1	3
Topography, II	2	4	6
Geodesy	2	4	6
Roads and materials of construction	2	4	6
Geology	2		2
Agricultural botany	2		2
Total	12	13	25

At the close of the year the students prepare their theses for the diploma of agrimensor (surveyor).

The following program shows the specialized studies pursued by the students of electrical and hydraulic engineering and the number of hours a week given to theoretic and practical exercises for the succeeding years:

Courses in electrical and hydraulic engineering.

ELECTRICAL ENGINEERING

Subjects	Hours a week.		
	Theoretical.	Practical.	Total.
THIRD YEAR.			
Practical work in physics, I		3	3
Practical work in physics, II		3	3
Electrotechnics	2	4	6
Mechanics	2	4	6
Law	2	1	3
Resistance of materials, I	2	4	6
Materials of construction	1	2	3
Total	9	21	30
FOURTH YEAR.			
Electrical machines	2	4	6
Practical work in electrotechnics		6	6
FOURTH YEAR—contd.			
Machines, first group	2	4	6
Building construction	2	4	6
Hydraulics	2	4	6
Total	6	22	30
FIFTH YEAR.			
Factories and workshops	2	4	6
Machines, second group	2	4	6
Industrial technology	2	2	4
Machines, third group	2	4	6
Total	8	14	22

HYDRAULIC ENGINEERING.

THIRD YEAR.			
Mechanics	2	4	6
Law	2	1	3
Topography, II	2	4	6
Resistance of materials	2	4	6
Roads and materials of construction	2	4	6
Geology	2		2
Agricultural botany	2		2
Total	14	17	31
FOURTH YEAR.			
Electrical machines	2	4	6
Machines, first group	2	4	6
Resistance of materials, second part	2	4	6
Building construction	2	4	6
Hydraulics	2	4	6
Total	10	20	30
FIFTH YEAR.			
Machines, second group	2	4	6
Construction of wood and masonry	2	4	6
Constructions of iron and reinforced concrete	2	4	6
Machines, third group	2	4	6
Total	8	16	24
SIXTH YEAR.			
Agricultural hydraulics	2	4	6
City and rural drainage	2	4	6
Interior navigation	2	4	6
Sea and river harbors	2	4	6
Total	8	16	24

The students of electrical engineering at the conclusion of the fifth year, and the students of hydraulic engineering at the conclusion of the sixth year, present a thesis for the diploma in their respective specialties. The diploma of hydraulic engineer also entitles to the exercise of the profession of surveyor.

In order to obtain the degree of civil engineer, the electrical and hydraulic engineers must pursue additional studies. The degree of civil engineer entitles to the conduct of work in general engineering,

surveying, and architecture, and is therefore highly desirable for graduates.

Electrical engineers, in order to qualify for the degree of civil engineers, must study, in addition to their ordinary curriculum, road building and geodesy, constructions of wood and masonry, constructions of iron and reinforced concrete. Moreover, they must complete the sixth year of special studies by the following program: Agricultural hydraulics; city and rural drainage; interior navigation; tramways, and architecture (second part).

The hydraulic engineers, aspiring to the degree of civil engineer, must pursue the following additional studies: Geodesy and architecture, first course; architecture, second course; and tramways.

Facilities for practical work.—Opportunities for practical instruction afforded by the engineering sections of the university are limited to physical and chemical laboratories and such other facilities as are provided by the Museum of La Plata, connected with the institution. The obvious difficulties incidental to the establishment of costly plants are increased by the dominant views favoring pure science and by the aversion to all forms of manual training, especially in higher studies.

The university has an arrangement with the General Electric Co., of New York, for the employment of practicing students of electrical engineering. A thermo-electrical plant and a hydraulic experimental station will be soon erected. The plans for these two adjuncts were approved in 1912.

SCHOOL OF ENGINEERING, PORTO ALEGRE.

The School of Engineering at Porto Alegre, Brazil, combines all the stages of complete technical education, beginning with an elementary school and ending with specialized courses in several branches of engineering. The programs of these courses compare favorably with those of the higher technical schools in Europe or the United States. The institution also comprises industrial courses of elementary and secondary order, organized in several divisions, and a semiclassical gymnasium.

All these schools form a closely centralized group, under common management and serving the same purpose which, as defined by the statute, is that of "preparing citizens capable of being useful to society and their native country through their work and training." This system appears to have some unquestionable advantages; the control possessed by the institution over the education preceding the proper engineering courses offers a guaranty that the preparation of the students entering the latter is fully in accord with the requirements of higher technical studies. The industrial courses affiliated

with the institution derive invaluable benefit from the accessibility of its laboratories, collections, and institutes, as well as selected teaching forces.

The group of schools designated as Porto Alegre School of Engineering, offer the following courses:

Gymnasium (Instituto Gymnasial Julio de Castilhos) divided into three sections as follows:

1. Elementary course of three years comprising the ordinary elementary subjects:

2. Intermediate course of two years; this comprises the study of five languages (Portuguese, French, Italian, German, and English), geography, history, civics, natural sciences, hygiene, mathematics, drawing, manual training, music, gymnastics, and military drill.

3. Secondary course of four years, comprising the study of the above five modern languages, Latin, elective Greek, history, civics, natural sciences, mathematics, elements of agriculture, accounting and bookkeeping, drawing, gymnastics, manual training, music, fencing, and military drill.

Industrial school (Instituto Tecnico Profissional) intended to prepare foremen and superintendents for industrial plants. It comprises the following courses:

1. Elementary course of four years, similar to the elementary course of the gymnasium, but with a marked emphasis on mathematical and practical subjects.

2. Technical course of five years, comprising the following subjects: The five modern languages, arithmetic, algebra, geometry, trigonometry, mechanics (general and applied), physics, chemistry, machinery, metallurgy, technology, drawing, descriptive geometry, sketching, perspective, shades, music, gymnastics, and work in factories.

The technical course is divided into several departments differing in respect to time assigned to the theoretical subjects and the character of practical exercises. There are eight distinct departments, viz: Metal working, wood working, construction, typography and printing, bookbinding, electrochemistry, lithography, and phototechnics.

Engineering institute (Instituto de Engenharia) offers the following courses:

1. Preparatory course of three years, comprising the subjects usually studied in the first two years of higher technical schools. The instruction is mostly theoretical. No specialization is evident in this course; the students perfect themselves in higher mathematics, drawing, and become familiar with methods of scientific study and research.

2. Course of civil engineering, covering three years. It corresponds to the specialized part of the course of standard higher schools of civil engineering in the leading countries. Several lines of specialization are gradually developed during the course, ending with competitive examination in projects in the following branches: Architecture, interior navigation, mechanical engineering, iron bridges, applied electricity, and maritime construction.

3. Course of electrical engineering, covering four years. It is organized on a different plan from the engineering course in that it comprises a complete electrical engineering curriculum within its four years of instruction, without a separate preparatory course. Specialization begins as early as the second year, and throughout the course considerable time is devoted to practical exercises. In the fourth year, in addition to the special subjects, political economy, finance, and administration are studied.

4. In connection with the school of electrical engineering there is a six-year course for electricians (Curso de Montadores Electricistas Mecanicos), corresponding in scope to the industrial courses considered above.

The *Institute of Agronomy and Veterinary Medicine* offers the following courses:

1. Course for engineers in agronomy, covering five years.

2. Course of veterinary medicine, covering five years.

3. Course in agronomy (agricultural course of high-school grade), covering three years.

4. Course for rural wardens, covering three years, of the same scope as the foregoing, but specially designed to train administrators of scientifically conducted farms and plantations.

The institute owns considerable real estate and other valuable property which is inalienable under the laws of the State. It is endowed with well-equipped laboratories, shops, etc., and is in agreement with a number of private industrial plants for practical work of students.

BIBLIOGRAPHY.

CANADA.

École Polytechnique de Montréal. Conditions d'admission, règlements et programme des cours. Montreal, 1915. 122 p. 8°.

——— Génie civil, architecture, arts décoratifs et industriels. Extraits du prospectus général. École de preparation. 16 p. 16°.

McGill University, Montreal. Calendar for session 1915–16. Montreal, 1915. lv, 445 p. 8°.

Nova Scotia Technical College. Short courses. January 5 to March 6. 16 p. double. 8°.

Royal Commission on Industrial Training and Technical Education. Report of the Commissioners. Parts I and II. Ottawa, printed by C. H. Parmelee, 1913. xiv, 437 p. 8°. [3d. George V. Sessional Paper, No. 191d. A. 1913.]

——— ——— ——— Part IV. xxv, 2354+29 p. 8°.

School of Mining, Kingston, Ontario. Calendar, 1913–14. Kingston, 1913. 121 p. 8°.

L'Université Laval. Annuaire pour l'année académique, 1915–16. Quebec, 1915. 219+68 p. 8°.

——— École Polytechnique. Lois organiques. Quebec, 1913. 12 p. in French, and 12 p. in English.

University of Toronto. Calendar, 1913–14. Toronto, 1913. 659+111 p. 8°.

——— Calendar, 1915–16. Miscellaneous curricula. Toronto, 1915. 36 p. 8°.

——— Curriculum for junior matriculation, 1915–16. Toronto, 1915. 38 p. 8°.

——— Faculty of Applied Science and Engineering. Calendar, 1915–16. Toronto, 1915. 175 p. 8°.

——— Faculty of Arts. Calendar, 1915–16. Toronto, 1915. 214 p. 8°.

——— Faculty of Forestry. Calendar, 1915–16. Toronto, 1915. 24 p. 8°.

FRANCE.

Astier, Claude Alexandre. L'enseignement technique, industriel et commercial en France et à l'étranger. Paris, 1908. 498 p. 8°.

Melon, Paul. L'enseignement supérieur et l'enseignement technique en France. Groupes universitaires, facultés, écoles spéciales, techniques, etc. Paris, 1893. 342 p. 8°.

Office National des Universités et Écoles Françaises, Paris. Les universités et les écoles françaises; enseignement supérieur, enseignements techniques, renseignements géneraux. Paris, 1914. 299 p. 8°.

Sénat. Debats parlementaires. Sess. ord. de 1916. Paris, 1916. p. 760.

Université de Lille. Programme des conditions d'admission et de l'enseignement à l'institut électrotechnique de Lille. Paris, Librairie Vuibert. 36 p. 8°.

Similar programs are published by other universities having technical departments. Programs of instruction for individual technical schools are published by the Librairie Vuibert, Paris, 63 Boulevard Saint Germain, also by Delalain Frères, 56 Rue des Écoles, Paris.

Vuibert, H. Annuaire de la jeunesse. 25 me Année, 1914. Paris, 1914. 1193 p. 16°.

GERMANY.

Aix-la-Chapelle. K. Technische Hochschule. Denkschrift verfasst aus Anlass der Industrie- und Gewerbeausstellung, etc. Aix-la-Chapelle, 1902. 88 p. 8°.

Bestimmungen für die Technischen Hochschulen in Deutschland. Halle, a. S., 1904. 319 p. 8°.

Grossherzogliche Technische Hochschule zu Darmstadt. Programm für das Studienjahr, 1914–15. Rektoratsübergabe. Darmstadt, 1914. 126 p. 8°.

Herzogliche Technische Hochschule Carolo Wilhelmina zu Braunschweig. Programm für das Studienjahr, 1914–15. Braunschweig, 1914. 91 p. 8°.

Königliche Technische Hochschule zu Berlin. Programm für das Studienjahr, 1913–1914. Berlin, 1913. 153 p. 8°.

Lexis, W. A general view of the history and organization of public education in the German Empire. *Transl.* by G. J. Tamson. Berlin, 1904. 182 p. 8°.

Riedler, Alois. Die Technischen Hochschulen und ihre wissenschaftliche Bestrebungen. Berlin, 1899. 17 p. 8°.

GREAT BRITAIN.

Board of Education. Preparatory schools for boys: their place in English secondary education. London, 1900. xv, 531 p. 8°. (Special reports on educational subjects, vol. 6.)

Edinburgh University. Calendar, 1915–16. Edinburgh, 1915. 829 p. 8°.

Heriot-Watt College, Edinburgh. Calendar, 1915–16. Edinburgh, 1911. 458 p. 8°.

Imperial College of Science and Technology, London. Calendar, 1915–16. London, 1915. 117 p. 8°.

Manchester. Municipal School of Technology. Prospectus of part-time courses in mathematics, physics and natural science. Session, 1915–16. Manchester, 1915. 29 p. 8°.

——— ——— Prospectus of part-time courses in mechanical and electrical engineering. Session, 1915–16. Manchester, 1915. 54 p. 8°.

——— ——— Prospectus of part-time courses in mining. Session, 1915–16. Manchester, 1915. 13 p. 8°.

——— ——— Prospectus of part-time courses in municipal and sanitary engineering, architecture and building. Session, 1915–16. Manchester, 1915. 70 p. 8°

——— ——— Prospectus of part-time classes in printing and photographic technology. Session, 1915–16. Manchester, 1915. 31 p. 8°.

Royal Technical College, Glasgow. Calendar, 1915–16. Glasgow, 1915. 516 p. 8°.

University of Manchester. Faculty of Technology. Prospectus of university courses in the Municipal School of Technology. Session, 1915–16. Manchester, 1915. 91 p. 8°.

AUSTRIA.

Kais. Königl. Deutsche Franz Joseph Technische Hochschule zu Brünn. Programm für das Studienjahr 1914–1915. Brünn, 1914. 292 p. 8°.

K. K. Technische Hochschule in Graz. Program für das Studienjahr 1913/1914.— I Teil. Gesetzliche Bestimmungen, Verzeichnis der Vorlesungen und Übungen, Studienpläne, Personalstand, Staats-Prüfungs-Kommissionen und Stundenpläne. Graz, 1913. 85 p. 8°.

Program Cís. Král. České Vysoké Školy Technické v Praze, na studijní rok 1913–1914. Část prvá: Seznam přednášek a cvičení. Studijní a hodinové rozorhy. Stipendi. v Praze, 1913. 128 p. 8°.

JAPAN.

Department of Education. Education in Japan. Prepared for the Louisiana Purchase Exposition, at St. Louis, U. S. A. Tokyo. 1914. 26+73+34+53+17+101+13+30+33 p. 8°.

——— Prepared for the Louisiana Purchase Exposition . . . Tokyo, 1914. 187 p. 8°.

——— Minister of State for Education. 40th annual report, 1912–13. (abridged.) Tokyo, 1915. 333 p. 8°.

Higher Technological School of Tokyo. Handbook. Tokyo, 1909. 55 p. 8°.

Kikuchi, *Baron* Dairoku. Japanese education. Lectures delivered in the University of London. London, 1909. p. 397. 8°.

Port Arthur Technical Institute. Calendar, 1911–12. Port Arthur, 1911 (?). 14 p., 8°

Tokyo Higher Commercial School. Yearbook, 1908–9. Tokyo, published by the Tokyo Higher Commercial School, 1908 (?). 44 p. 8°.

Tokyo Imperial University Calendar, 1913–14. Tokyo, published by the University. 1913 (?). vi, 296+349 p. 12°.

——— College of Agriculture. Catalog. 1914–15. (Abridged English edition.) Sapporo, Japan, 1914 (?). 73 p. 8°.

RUSSIA.

Ministerstvo Finansov. Rossija v konce XIX vieka. Pod obshtsheyu redakcyeyu V. I. Kovalevskago. S. Peterburg. 1900. 968 p. 8°.

Ministerstvo Putej Soobshtshenja. Zhurnal. 1900. Kniga [illegible]vertaja. S. Peterburg, 1900. p. 191. 8°.

——— Zhurnal, 1900. Kniga tretia. S. Peterburg, 1900. p. 192. 8°.

SOUTH AMERICA.

Escola de Engenharia de Porto Alegre. Regulamento do Instituto de Electro-Technica. Porto Alegre, 1914. 29 p. 8°.

——— Regulamento do Instituto de Engenharia. Porto Alegre, 1913. 23 p. 8°.

——— Regulamento do Instituto Technico Profissional. Porto Alegre, 1913. 57 p. 8°.

Estados Unidos do Brazil. Estado do Rio Grande do Sul. Estatutos da Escola de Engenharia do Porto Alegre. Porto Alegre, 1912. 23 p. 8°.

INDEX.

Admission requirements, 25, 31, 36, 41-42, 58, 64-65, 73, 80, 84, 88, 93, 96, 104.
Anderson University, Scotland, 38.
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Architecture, Laval University, Canada, 107; Technical High School of Berlin, 22-23.
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Commercial schools, Russia, 79-80.
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